Corridor Program
Congestion Relief & Bus Rapid Transit Projects

APPENDIX H1
PRELIMINARY HYDRAULICS REPORT

I-405, SR520 to SR522 Stage 1
(Kirkland Stage 1)

Draft RFP
March 22, 2005

Washington State
Department of Transportation

Project Team
Congestion Relief & Bus Rapid Transit Projects

PRELIMINARY HYDRAULIC REPORT

I-405 Corridor

CONGESTION RELIEF AND BUS RAPID TRANSIT PROJECTS

KIRKLAND NICKEL PROJECT

I-405, SR520 to SR522

Stage 1 and 2

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

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March 22, 2005

Washington State
Department of Transportation

Signature Sheet

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The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed above.

Keith Hixson, P.E.

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1 INTRODUCTION

1.1 PURPOSE

The hydraulic report is intended to serve as a complete documented record containing the engineering justification for all drainage modifications that occur as a result of the project.

The construction work for the I-405 Corridor projects will be done by the “design-build” process. The design and construction details for each contract will be prepared by the design-builder. Accordingly, there will be a “Preliminary Hydraulic Report” prepared by the WSDOT I-405 Corridor design team and a “Final Hydraulic Report” to be written by the design-builder. The preliminary hydraulic report defines the proposed drainage collection and treatment concept to a level of detail confident that it is constructible and permitable. The preliminary hydraulic report will provide the design-build contractor a basic drainage concept on which to base his bid quantities and costs with the assurance that this design meets the project permit requirements.

The final hydraulic report will be prepared by the design-builder to reflect the final design and/or as-built configurations for the project. The final hydraulic report is expected to refine the preliminary report’s concepts to the detailed construction plan level that is normally associated with a hydraulic report. The requirements for a project’s “final” hydraulic report will be included in the design-builders contractual scope-of-work and specifications.

In general, the stormwater reports for the I-405 Corridor projects will be prepared on a project-by-project basis as stand-alone documents. However, the preliminary hydraulic reports for the phased projects will contribute to and fit within an overall I-405 corridor drainage scheme, according to the overall I-405 master plan. This will help to minimize any drainage facility abandonment and reconstruction required by a phased installation program.

1.2 PROJECT DESCRIPTION

I-405 is the second-most traveled corridor in Washington carrying over 600,000 people and averaging up to 12 hours of gridlock every day. Responding to the transportation crisis within the I-405 corridor, the Washington State Department of Transportation (WSDOT) brought together every city and transportation agency having jurisdiction within those boundaries to help formulate the I-405 Corridor Program. The program’s goal is to create a comprehensive strategy to reduce congestion and improve mobility along I-405.

To fix the areas of worst congestion, specific projects will be completed to produce continuous multi-modal corridor improvements from I-5 in Tukwila (MP 0.0) to I-5 near Lynnwood (MP 30.3). The I-405 Master Plan (20-yr vision) will ultimately add up to 2 lanes, plus auxiliary lanes in each direction along its 30 mile length. The freeway design includes a buffer separating the general-purpose lanes and the high-occupancy vehicle (HOV) lane, and it provides for implementation of a bus rapid transit system operating in the improved HOV lanes. Along with improving key arterials, the corridor will accommodate an additional 110,000 trips per day, reduce time stuck in traffic by over 13 million hours per year, and improve safety for the traveling public.

The corridor Environmental Impact Statement was developed after a lengthy public review and input process, and reached a Federal Record of Decision (ROD) in October, 2002. The EIS and ROD provided that project improvements contained within the Selected Alternative would be reexamined individually and in combination for phased implementation. This hydraulic report is for one of several projects being advanced as part of a phased implementation of the Selected Alternative.

1.2.1 I-405 CORRIDOR

1.2.1.1 GENERAL DESCRIPTION

The I-405 Corridor encompasses about 230 square miles and extends on both sides of I-405 from its southern connection to I-5 at Tukwila, to its northern intersection with I-5 in Snohomish County, north of Lynnwood. Interstate 405 is the region's dominant north-south travel corridor east of Interstate 5 and it is the designated military route due to I-5 being deemed too constricted. At present, I-405 varies from six to ten lanes along the 30 mile corridor.

The unique geographic features such as lakes, steep hills and rivers that define western Washington also present bottlenecks and barriers to an effective transportation system. This has created a situation where the I-405 highway serves as the principal means of transportation for local communities, cities and areas of unincorporated King and Snohomish counties. The roadway network of I-405 reflects the local geography and development patterns that have occurred over the years. I-405 has changed dramatically, from a Seattle bypass in the 1960s, to the roadway of choice for most north-south trips east of Lake Washington. The majority of trips on I-405 begins and ends within the corridor itself. The remaining trips often lead to communities to the south along State Route 167 and developing areas to the east in the Cascade foothills. This has lead to situations within the corridor where the highway is at a level of service of D or worse, with bumper-to-bumper, gird-locked traffic for periods of 12 hours and more each day. Major local arterials have also become heavily congested as the areas population and employment has grown.

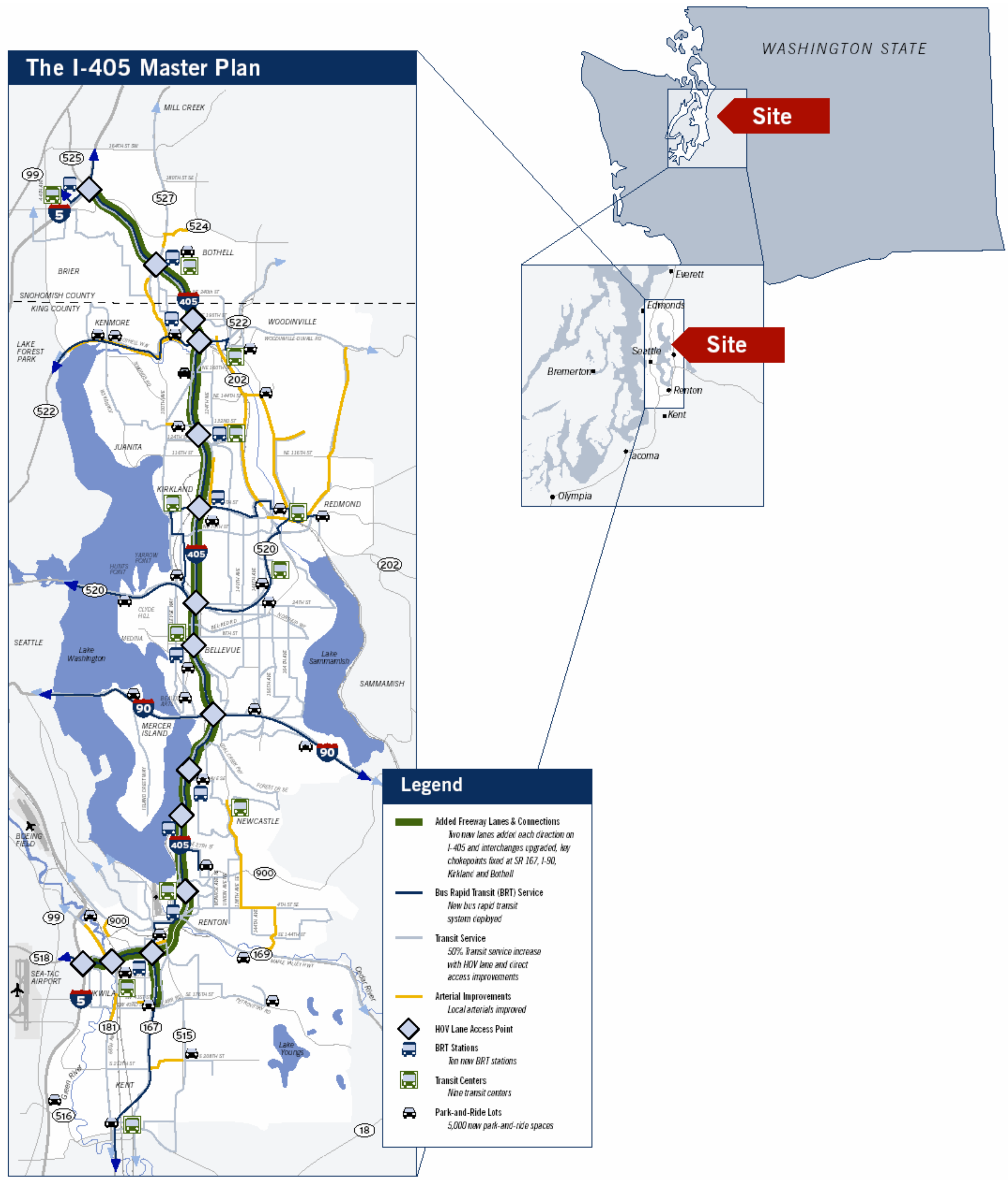
The I-405 Corridor is bound by Lake Washington to the West and the foothills of the Cascade Mountains to the East. The land forms found within the I-405 corridor are heavily influenced by multiple Pleistocene glaciations that resulted in a series of north-south-trending ridges of glacial drift separated by deep troughs. The troughs are now occupied by lakes and streams and their associated alluvial and lacustrine deposits. Major surface water features include two large lakes, three rivers, eleven major streams, and numerous smaller lakes and streams.

The corridor area lies within two state Water Resource Inventory Areas (WRIAs). The southern ten percent lies within WRIA 9 – Green-Duwamish River Basin. The remainder lies within WRIA 8 – Lake Washington Basin (Cedar-Sammamish rivers). Both WRIAs drain to Central Puget Sound a few miles downstream of the study area. The upper portions of the Green and Lake Washington basins have undergone relatively little development and most of the land cover is second-growth forest. The lower portions of these basins, in contrast, have undergone extensive land use changes in the form of either agriculture or urban and residential development. Similarly, the basins of the major streams in the study area are also largely developed or are experiencing relatively rapid growth.

The highway for the most part is located in the lower elevations of the Lake Washington watershed, and thus intersects a number of contributing rivers, streams and smaller tributaries. Within the Kirkland Segment, these include the Sammamish River, Juanita Creek and its tributaries, Forbes Creek and its tributaries, and Yarrow Creek.

There is no substantial regional groundwater flow system. Instead, groundwater movement is generally from topographic high to topographic low, usually toward stream drainages. Groundwater in the uppermost aquifer unit generally occurs under water table conditions; groundwater in the deeper units is semiconfined. Recharge is generally in higher elevation areas where semiconfining layers are not present, and groundwater discharges to stream drainages.

I-405 Corridor Location Map, Exhibit 1



1.2.1.2 THREE-PHASED PROGRAM

The corridor improvements are proposed to be done in three phases. Phase I are immediate "Nickel" Projects funded by a $0.05 gas tax authorized by the state legislature in 2003. For I-405 these initially include: a) adding one lane in each direction between I-90 and Bellevue; b) improving the SR-167 Interchange in Renton by adding one lane in each direction to the I-405 mainline; and c) adding one lane in each direction in the Kirkland area, basically between SR-520 and SR-522.

Phase II is a 10-year "Implementation" plan, that depending on funding source outcomes, will provide continuous corridor improvements from I-5 in Tukwila to SR-522 in Bothell. Projects include adding one lane each direction from I-5 to SR-181; adding two lanes each direction from SR-181 to I-90; adding one lane in each direction from I-90 to SR-522; adding one lane in each direction between I-405 and S 180th street on SR-167; and construct a bus rapid transit line with stations, HOV direct access ramps, park-and-ride lots and bus service. Improvements include mainline realignment, interchange and secondary roadway improvements that improve the overall traffic flow, as well as providing for environmental enhancements and collection and treatment of runoff from the impervious project surfaces.

Phase III will complete the improvements to the 20-yr Master Plan vision, as discussed above.

1.2.1.3 CORRIDOR SECTIONS

For purposes of design and construction administration, the overall project is divided into regional sections as follows:

- S. Renton / Tukwila Section– MP 0.00 (I-5 in Tukwila) to MP 3.32 (between Benson Road and Cedar Ave)
- N. Renton Section– MP 3.32 to MP 10.29 (north of Coal Creek Parkway I/C)
- Bellevue Section- MP 10.29 to MP 15.90 (boundary between Bellevue and Kirkland Municipalities)
- Kirkland Section- MP 15.90 to MP 25.00 (King/Snohomish County Line)
- Bothell Section- MP 25.00 to MP 30.24 (I-5 and Swamp Creek I/C in Lynnwood)

1.2.2 DESIGN-BUILD PROCESS

The construction work for the I-405 Corridor projects will be done by the design-build delivery process. Design-build construction simply means that a single entity is responsible for both design and construction of the project. The designer-builder may be a single entity, a joint venture or an affiliate team.

Design-build provides a project delivery process that creates a fast-track system where project construction can be initiated concurrent with, or immediately following the detailed design phase. Design-build, typically faster than the traditional design-bid-build process, combines the design and construction of a project into one contract. The designing firm and construction contractor become a team, working together on the design and construction phases of a project concurrently.

There are a number of important differences in the relationships and legal responsibilities between the owner and the contractor and designer for the design-build contract from what is normally expected in the design-bid-build process. While not going into all of these differences here, it is important to list what issues will develop for the drainage design and construction, and how that relates to the purpose and content of this report, as follows:

- This Preliminary Hydraulic Report defines a proposed drainage collection and treatment concept. The intent of this report is to provide a concept level plan that it is constructible, aligned with local agency coordination to date, are consistent with future phases of work in the segment, and provide the basis for permitting and land acquisition. The permanent runoff treatment concepts described herein have been included in the environmental assessment (EA) report and in the project permit applications. The intent is that the project permits will be applied for and obtained by WSDOT prior to issuing of the design-build contract.
- This Preliminary Hydraulic Report will be a reference document for the design-build contract request for proposals (RFP) to provide the design-build contractor a basic drainage concept on which to base his bid quantities and costs. If the design-builder elects to follow the runoff treatment and conveyance concepts described herein, he will be proceeding with better assurance that his final drainage design will be accepted by the reviewing agencies in accordance with the project permits.
- The design-build contractor is not limited to using the specific concepts defined in this Preliminary Hydraulic Report. There could be other alternatives and best management practices (BMPs) that still meet the design-build contract RFP criteria and permits that may be preferred by the design-builder from a cost and constructability stand-point. However, alternative drainage designs will have to be done within the general framework of the specified criteria and guidelines. Design-builder proposals must also comply with the project permits. If not, then it would become the design-builder's responsibility to obtain the necessary permit approvals and/or permit revisions, if these proposed concepts are accepted by the owner.
- The design-builder will be responsible to prepare a Final Hydraulic Report. The requirements for the project's hydraulic report will be prepared per the WSDOT Hydraulic and Highway Runoff Manuals, and in accordance with the design-build contract.
- The Final Hydraulic Report will be prepared by the design-builder to reflect the final design configurations for the project. The Final Hydraulic Report is expected to refine, adjust, or replace the preliminary report's concepts to the detailed construction plan level that is normally associated with a hydraulic report.
- The Final Hydraulic Report will be required for WSDOT's review and acceptance of the design-builders storm drainage design. A 30% draft of the report will be submitted prior to the start of drainage construction to provide the design-builder's overall concept for the drainage design for review. Typically, this will occur early in the project, as the design-build team usually wants to start as soon as possible with construction activities. The first major items of work are the footprint earthwork and in-ground utilities/drainage system. Thus, construction begins in the design-build process with partially completed plan sets, where the footprint earthwork and drainage system design will be some of the first plans to be issued for construction. The design-builder may want to begin drainage installation on specific elements of the system. Prior to being issued for construction, the drainage design for that element should be submitted to WSDOT for review. The submittal should include the detailed calculations and supporting documentation such that it can be reviewed by WSDOT and comments incorporated into the Design-Builder's final design of that element. Design of the specific element should fit within the previously submitted 30% complete Hydraulic Report concept; otherwise the concept should be revised and included in another Hydraulic Report draft submittal (60%

complete). The 100% complete submittals of the Hydraulic Report should be done as early as possible during the design-build installation, incorporating the final drainage design.

- Supplements to the Final Hydraulic Report will be prepared by the Design-Builder. The supplements will include all revisions of the Hydraulic Report, including all supporting calculations and exhibits to reflect revisions to the final design and the as-built conditions as a permanent record.

1.2.3 KIRKLAND NICKEL PROJECT DESCRIPTION

The Kirkland Nickel Project generally extends from the on-off-ramps on the north side of the I-405 interchange with SR-520, along the I-405 corridor, and ends at approximately the on-off-ramps on the south side of the I-405 interchange with SR-522 (see Kirkland Nickel Location, Exhibit 2).

Since the proposed improvements are not uniform throughout the project area, the project description has been broken into geographic units that can be easily identified while driving along I-405. The following project description has been written as if the reader is first driving northbound on I-405 from the interchange with SR-520 to the interchange with SR-522 and then turns around and drives southbound back to the interchange with SR-520.

1.2.3.1 TRAVELING NORTHBOUND:

From SR-520 to the NE 70th Street Interchange

- No improvements are proposed in this area (4 general purpose lanes (GP) + 1 high occupancy vehicle (HOV) existing).

From the NE 70th Street Interchange to the NE 85th Street Interchange

- 1 Additional General Purpose Lane (4 GP + 1 HOV when completed). The existing drop lane from the NE 70th Street off-ramp will become a through lane.

From the NE 85th Street Interchange to the NE 116th Street Interchange

- 1 Additional General Purpose Lane (4 GP + 1 HOV when completed). The existing bridges over NE 85th Street will remain unchanged. The additional lane will be accommodated over these bridges by re-striping, resulting in narrow lanes and shoulders.
- For improvements at the 116th Street interchange, see 'Interchanges' below.

From the NE 116th Street Interchange to the NE 124th Street Interchange

- The Additional General Purpose Lane added approaching from the south will become a drop lane (exit only) at NE 124th Street.
- North of the NE 124th Street off-ramp, the roadway will remain as 3 GP + 1 HOV.

From the NE 124th Street Interchange to the NE 160th Street Interchange

- No improvements are proposed in this area (3 GP + 1 HOV existing).

From the NE 160th Street Interchange to the SR-522 Interchange

- No improvements are proposed in this area (3 GP + 1 HOV existing).

1.2.3.2 TRAVELING SOUTHBOUND:

From the SR-522 Interchange to the NE 160th Street Interchange

- 1 Additional General Purpose Lane (4 GP + 1 HOV when completed). The additional lane will connect to the existing merge lane from the east bound SR-522 connector.

From the NE 160th Street Interchange to the NE 124th Street Interchange

- 1 Additional General Purpose Lane (4 GP + 1 HOV when completed).
- The Nickel project ties into the proposed NE 128th Street HOV Direct Connect Project. By reconstruction of the SB on-ramp from NE 160th St.

From the NE 124th Street Interchange to the NE 116th Street Interchange

- 1 Additional General Purpose Lane (4 GP + 1 HOV when completed).
- For improvements at the 116th Street interchange, see 'Interchanges' below

From the NE 116th Street Interchange to the NE 85th Street Interchange

- 1 Additional General Purpose Lane (4 GP + 1 HOV when completed). The existing bridges over NE 85th Street will remain unchanged. The additional lane will be accommodated over these bridges by re-striping, resulting in narrow shoulders.

From the NE 85th Street Interchange to the NE 70th Street Interchange

- 1 Additional General Purpose Lane (4 GP + 1 HOV when completed).

From the NE 70th Street Interchange to the SR-520 Interchange

- 1 Additional General Purpose Lane (4 GP + 1 HOV when completed). The additional lane will tie into the existing add lane for the connection to the SR-520 interchange.

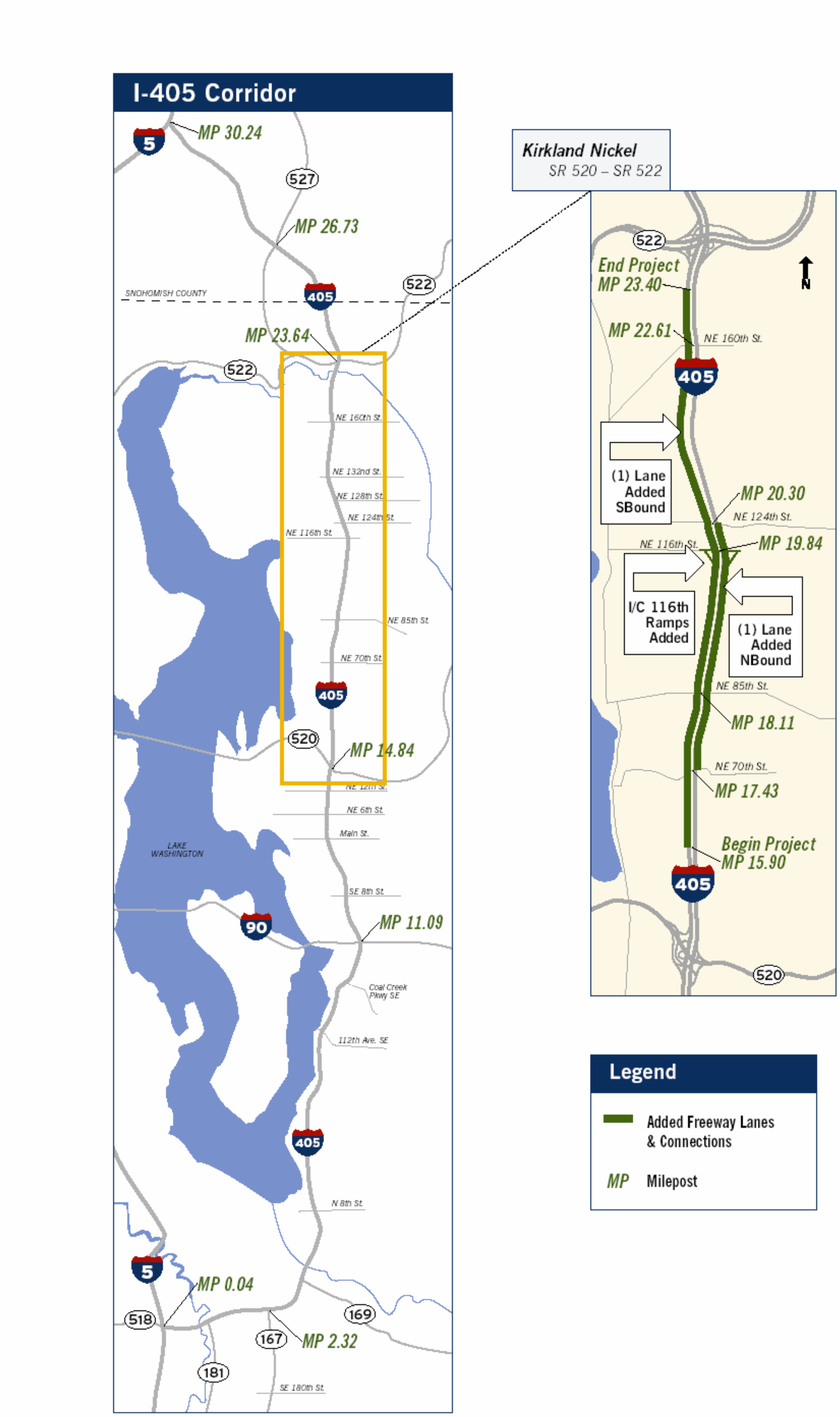
1.2.3.3 INTERCHANGES:

Improvements in the Kirkland Nickel segment will predominantly occur along the freeway mainline having little or no impacts to the existing interchanges with the exception of NE 116th Street.

<u>NE 116th Street Interchange</u>

- Reconstruct the 116th Street Interchange into a single point urban interchange (SPUI). This option would construct the complete interchange according to the I-405 Implementation Plan, accommodate the Nickel widening, and correct the existing non-standard crest vertical curve on I-405. Design elements would include:
    1. Reconstruct the I-405 bridge over 116th Street at the Implementation Plan horizontal and vertical location. Bridge would be built to Nickel width and require simple widening to complete the mainline Implementation Plan.
    2. Reconstruct the NB off-ramp and SB on-ramp as the Implementation Plan ramps. No additional ramp work would be necessary for the Implementation projects.
    3. Widen NE 116th Street from 1700 feet west to 900 feet east of I-405 to accommodate dual turn entrance and exit ramps.
    4. Reconstruct the NE 116th Street bridge over the BNSF railroad.
    5. Reconstruct the 120th/116th intersection to accommodate an additional E/B through lane on NE 116th Street, and improve turning radii at corners.

Kirkland Nickel Location, Exhibit 2



1.2.3.4 CONSTRUCTION ACTIVITIES

Due to funding availability, the Nickel project will be constructed in two stages, and under two separate design-build contracts. The first stage will include those portions of the freeway between NE 85th Street interchange and NE 124th Street interchange. Major construction activities in Stage 1 include the following:

- Site preparation work including shifting and maintaining traffic
- Implementation of Temporary Erosion and Sediment Control systems
- Construction of two new bridges, retaining walls, additional freeway lanes, and reconfiguration of the NE 116th Street interchange
- Improvements to the NE 116th Street storm drainage system and other affected utilities
- Construction of detention vaults and ponds in the freeway right-of-way
- Construction or augmentation of existing freeway storm drainage facilities and conveyance features
- Construction of Ecology Embankment water quality treatment facilities

Stage 2 includes all Nickel project work south of the NE 85th Street interchange from the beginning of the Kirkland section (milepost 15.90), and north of the NE 124th Street interchange to the project section terminus at milepost 23.4. Major activities for Stage 2 construction include the following:

- Site preparation and temporary traffic maintenance configurations
- Implementation of Temporary Erosion and Sediment Control systems
- Construction of retaining walls, additional freeway lanes and interchange adjustments
- Reconstruction or adjustments of cross culverts and impacted municipal storm drains and utilities
- Construction of freeway drainage systems including inlets, culverts, trunk lines, ditches, curbing, and conveyance stabilization features
- Construction of flow control treatment facilities including detention ponds, infiltration systems, and detention vaults
- Construction of water quality treatment facilities including, Ecology Embankments, engineered wetlands, filter strips, wet vaults, wet ponds, infiltration and treatment trains

1.2.3.5 DRAINAGE PROPOSAL

This preliminary hydraulics report outlines a set of proposed storm drainage improvements that have been developed through the participation of many parties in a coordinated design effort. Record data has been collected and reviewed, design options have been developed and evaluated, local jurisdictions have been involved and coordinated, value engineering and cost validation studies have been performed; all done with the intent to identify and provide the best storm water design solutions. The primary intent for drainage along the freeway corridor is to provide collection and conveyance systems to remove surface water from the pavement per WSDOT criteria and provide for the safety of the motoring public. Additionally, storm drainage designs are developed to attain the greatest environmental benefit for the greatest economic value.

Since the Kirkland Nickel project for the most part is adding new lanes with minimal additional pavement, mostly located on the outside edges, the proposed design utilizes the existing system of inlets, storm drains and cross culverts wherever possible to minimize the disturbance of the existing pavement.

In several instances, new collection facilities will be placed where required outside of the new shoulder pavement areas, with runoff contained and rerouted to new treatment facilities. In few instances, portions of the Kirkland segment will be fitted with new drainage structures within the roadway, some in conjunction with roadside curbing and associated bypass systems to isolate freeway runoff from offsite runoff. Such adjustments are proposed to meet environmental standards with efficient treatment alternatives and to reduce related facility sizes, property acquisition needs and associated costs.

Low impact development (LID) best management practices (BMPs) are encouraged wherever possible for water quality treatment to "enhanced standards" due to the high volume of mainline traffic. Other water quality treatment BMPs may be applicable for this project as provided in the HRM standards. The goal is to minimize large isolated treatment facilities and maintain the existing drainage patterns within each drainage basin.

Runoff flow control should utilize infiltration wherever possible. This may be applied in the form of infiltration ponds, infiltration trenches, or in combined infiltration-detention facilities. Flow control detention may be provided in open ponds, concrete vaults, or other acceptable BMP facilities provided in the HRM. Vaults and ponds will be sized and constructed per the Nickel project needs, however they would be located such that they will be part of the future implementation stages of construction. Drainage systems should be laid-out to minimize disruption of existing pavement and traffic since much of the existing highway pavement is to be maintained for this first phase of the Kirkland section improvements.

Drainage design concepts presented here have been advanced to include enough detail as to represent solutions that are constructible and permitable. These design concepts will be further refined by the design-build team, who will prepare final construction plans and details for the project.

2 SITE CONDITIONS

2.1 DESCRIPTION OF EXISTING CONDITIONS

I-405 through the Kirkland Section was built traversing generally hilly terrain along side slopes as steep as two horizontal to one vertical. Prior to construction of the freeway, runoff flows were in a perpendicular direction across the I-405 alignment, which resulted in relatively short flow lengths. Freeway construction maintained the major flow patterns in culverts and cross drains. Minor flow routes were interrupted by freeway construction to be conveyed by roadside ditches and engineered conveyance systems to the cross culverts. The effect is to concentrate flows in cross culverts and major conveyance systems downstream of the freeway corridor.

Watershed basins remain relatively unaltered by the freeway corridor; generally divided by the relative rising and sinking terrain associated with the major stream conveyances. The Kirkland segment spans four watershed basins, beginning south to north, 1) Lake Washington East-Bellevue North, 2) Forbes Creek, 3) Juanita Creek, and 4) Sammamish River. For the purposes of this report for storm drainage analyses and design, the watersheds listed above are further subdivided into six minor watershed basins delineated by high and low points along the corridor profile. These six watersheds are further divided into Threshold Discharge Areas (eighteen total; associated with the various cross drains and outfalls along the corridor) for design and placement of storm water detention and water quality treatment facilities. Threshold discharge areas (TDAs) are defined as onsite areas draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flow path).

2.2 SOILS

2.2.1 GENERAL MAPPING

The soils and land types found within the I-405 corridor are heavily influenced by multiple Pleistocene glaciations that resulted in a series of north-south-trending ridges of glacial drift separated by deep troughs. The troughs are now occupied by lakes and streams and their associated alluvial and lacustrine deposits.

Many of the soils along the existing state highways and arterials have been modified by construction activities. The most prevalent soil type across the study area is the Alderwood complex. This is a gravelly, sandy loam that forms on glacial till. The permeability is relatively rapid above a hardpan layer, then very slow through it. Available water capacity is low. On slopes steeper than 25 percent, it has rapid runoff and a high erosion hazard.

An evaluation of site geology for the Kirkland Nickel project has been conducted and compiled in the following documents:

- Geotechnical Baseline Report, I-405, SR520 to SR 522, Project 1, File No. 0180-152-00, September 7, 2004
- Draft Geology, Soils, and Groundwater Discipline Report, June 2004, Version 1.

An evaluation of Regional geology for the corridor is discussed in detail in the I-405 Corridor Program Draft Geology and Soils Expertise Report (CH2M HILL, 2001). The King and Snohomish county soil surveys (Snyder et al., 1973; Debose and Klungland, 1983) provide detailed soil maps of the study area. These maps are generally representative of average conditions in the upper several feet of soil profile.

2.2.2 INFILTRATION

From the geotechnical explorations, it is assumed that infiltration can be utilized along portions of the Kirkland Nickel project. Preliminary exploration indicates glacial till underlying most of the proposed pond locations. Geologic formation and related soil types vary with site locations throughout the Kirkland segment. Limited exploratory borings and soil samples conducted for the Geotechnical Baseline Report are inconclusive as related to specific pond sites, however laboratory testing and analyses indicate that possibilities for infiltration exist along the corridor.

> "Using the ASTM D_{10} gradation results from laboratory tests on soil samples from the borings and Table 4-12 of the WSDOT (2004) "Highway Runoff Manual," the estimated long-term infiltration rate of the soils generally cannot be evaluated because the soils contain greater than 10 percent fines (silt and clay). For soils with greater than 10 percent fines, the long-term infiltration rate is less than 1 inch per hour. Additional laboratory testing, including hydrometer analyses, would be required to define the long-term infiltration rate using the ASTM D_{10} gradation methods, as the soils contain more than 10 percent fines. (silt and clay).

> An exception is one soil sample from boring KQ-1-04, located in the planned B4 Pond location. The soils sample consists of fill material that has a D10 of slightly greater than 0.1 millimiters. At this soil sample location, the estimated long-term infiltration rate is estimated to be about 2.0 inches per hour."

Lacking better data, preliminary sizing calculations of flow control facilities assumed that no infiltration would be used in developing the concepts contained in this report. However, based on the related geotechnical evaluations it is likely that opportunities for infiltration do exist in localized areas along the project corridor. <u>The Design-Builder will perform additional geotechnical investigations, in accordance with the WSDOT Highway Runoff Manual to better define the infiltration feasible areas and design rates for final design of the runoff detention facilities.</u>

2.3 DRAINAGE BASINS

2.3.1 MAJOR AND REGULATED FLOODPLAINS

Floodplain zones have been identified in the FEMA Flood Hazard Boundary Maps. Three flood plains have been identified for the I-405 Kirkland segment; 1) Forbes Creek tributaries, 2) Juanita Creek tributaries, and 3) Sammamish River. The 100-year flood plains indicate that the water overflowing the stream bank would have no adverse effect on the freeway, which is elevated at the stream crossings.

2.3.2 PROJECT AREA SUB-BASINS AND CATCHMENT AREAS

The Kirkland segment spans four watershed basins, beginning south to north, 1) Lake Washington East-Bellevue North, 2) Forbes Creek, 3) Juanita Creek, and 4) Sammamish River. For the purposes of storm drainage analyses and design, the watersheds listed above are further subdivided into six minor watershed basins delineated by high and low points along the corridor profile. These six watersheds are further divided into Threshold Discharge Areas (eighteen total; associated with the various cross drains and outfalls along the corridor) for design and placement of runoff treatment facilities. Table 2.1 lists the individual threshold discharge areas with their corresponding areas of analyses. Threshold discharge areas (TDAs) are defined as on-site areas draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flow path). The basin and TDA areas are identified on the drawings in Appendix A.

Table 2.1 Watershed Basins and Threshold Discharge Areas

Basin	TDA Area (acres)	Existing Impervious Area (acres) [1]	Net New Impervious Area (acres)
Lake Washington East / Bellevue North Watershed			
<u>Basin A</u>			
TDA-A1	113.80	58.30	1.08
TDA-A2	6.80	3.90	0.44
<u>Basin B</u>			
TDA-B1	19.15	7.19	0.01 [2]
TDA-B2	34.95	18.55	0.00 [2]
TDA-B3	18.31	8.20	0.00 [2]
TDA-B4	50.12	26.41	0.35
Total	**243.13**	**122.55**	**1.88**

Basin	TDA Area (acres)	Existing Impervious Area (acres) [1]	Net New Impervious Area (acres)
Forbes Creek Watershed			
Basin C			
TDA-C1	61.04	26.17	7.92
Total	**61.04**	**26.17**	**7.92**
Juanita Creek Watershed			
Basin D			
TDA-D1	73.91	42.35	0.57
TDA-D2	23.42	10.83	0.05 [2]
TDA-D3	19.56	5.40	0.53
TDA-D4	15.23	5.22	0.47
Basin E			
TDA-E1	15.55	6.72	0.83
TDA-E2	14.05	6.92	0.32
TDA-E3	24.42	5.16	0.00 [2]
Total	**186.14**	**82.60**	**2.77**
Sammamish River Watershed			
Basin F			
TDA-F1	13.10	6.66	0.20
TDA-F2	9.21	5.26	0.00 [2]
TDA-F3 & F4	43.01	19.89	0.79
Total	**65.32**	**31.81**	**0.99**
Project Total	**555.63**	**263.13**	**13.56**

[1] Includes I-405 mainline, interchanges, and surface streets
[2] Total net-new impervious surface below treatment threshold limit; HRM Chapter 2-3.6.3 and Appendix 5A

2.3.2.1 SUB-BASIN DESCRIPTIONS

Lake Washington East-Bellevue North: Six separate Threshold Discharge Areas have been identified for this watershed along the I-405 corridor (TDA-A1, TDA-A2, TDA-B1, TDA-B2, TDA-B3, and TDA-B4). Surface drainage along this portion of the Kirkland segment generally flows southwest following sloping terrain toward Lake Washington. Basin A stretches from the vicinity of Interstate 520 interchange and extends north to a relative high point on the corridor profile at NE 60th Street. Basin B extends north from NE 60th Street to the watershed boundary in the vicinity of the NE 85th Street interchange.

Within Basin A, the freeway is cut into the surrounding terrain, thus concentrating stormwater into parallel conveyance systems running south along the corridor. Yarrow Creek intercepts the corridor near the Bridal Trails neighborhood at approximate project station 4020 (milepost 16.1) further concentrating flows from the freeway and surrounding neighborhoods. Yarrow Creek continues down slope flowing south, crosses the freeway in the vicinity of the I-520 intersection, then west to Yarrow Bay and Lake Washington.

Basin B runoff discharges to the west in ditches and closed conveyance systems as part of the City of Kirkland drainage network. Flows from TDA-B1 converge with NE 60th Street conveyance system running west approximately 1-mile to Lake Washington. Flows from TDA-B2 and B3 converge near the NE 70th Street conveyance system flowing west to a nearby wetland, then continuing west approximately 1-mile to Lake Washington. TDA-B4 discharges runoff to the NE 85th Street interchange system and City of Kirkland network flowing to Lake Washington approximately 1-mile west.

Forbes Creek Watershed: This portion of the project contains a single Threshold Discharge Areas (TDA-C1). TDA-C1 begins at a high point just north of the NE 85th Street interchange and extends north to the NE 116th Street Interchange. Surface runoff from this portion of the Kirkland segment drains to Forbes Lake/Forbes Creek system, running west following ravines and sloping terrain to Lake Washington.

Southern Portions of TDA-C1 flow east to Forbes Lake and/or portions of Forbes Creek lying east of the freeway. Runoff from this area is conveyed in closed pipe systems and open ditches to converge with the Forbes Creek system. Continuing north, portions of TDA-C1 drain north through closed pipe systems and open ditches to the main stem of Forbes Creek where it crosses beneath the freeway mainline at project station 4181 (milepost 19.1). From the freeway crossing, Forbes Creek flows west through a deep undeveloped ravine which opens to a commercial/industrial development. At this point the creek enters a large culvert passing beneath a parking lot and discharges to an undeveloped City of Kirkland roadway right-of-way. At this point the creek flows west approximately 300 feet where it crosses beneath a BNSF railroad right-of-way, then turning south along the right-of-way for a short distance before spilling into another ravine continuing its path westward to Lake Washington approximately 1-mile downstream.

Extending north from the freeway culvert, runoff is conveyed through a series of closed pipe systems, open ditches, and cross culverts to converge with a tributary of Forbes Creek crossing the freeway at project station 4205 (milepost 19.6). This tributary continues west through open ditches and closed pipe systems to the BNSF railroad right-of-way, then flows south to converge with the main stem of Forbes Creek.

Northern portions of TDA-C1 drain through a series of ditches and pipes to a roadway conveyance system passing under the freeway at NE 116th Street. The City of Kirkland has expressed concerns regarding pipe constrictions and leaf clogging in the existing drainage system at NE 116th Street. The existing pipe system is predominately constructed of 24 inch pipe and conveys storm flows from a relatively large basin lying upslope east. Within the I-405 right-of-way, the pipe system discharges through an open ditch and drainage inlet fitted with a grated inlet that frequently experiences leaf and debris clogging during heavy autumn and winter rainfall events. The conveyance system continues west through successive 15 inch and 18 inch pipes for approximately 200 feet before transitioning again to 24 inch pipes. Once under the freeway, this pipe system turns south along the southbound onramp to converge with the Forbes Creek tributary described above.

Juanita Creek: This portion of the project contains seven separate Threshold Discharge Areas (TDA-D1, TDA-D2, TDA-D3, TDA-D4, TDA-E1, TDA-E2, and TDA-E3). Beginning at NE 116th Street, freeway runoff in TDA-D1 flows north through the roadway conveyance system or via overland flow to the BNSF railroad right-of-way crossing under the freeway, where it collects in track-side ditches and runs northeast, spilling through surface street conveyance systems to Totem Lake. Totem Lake drains to the adjacent wetlands west around and through the Totem Lake Mall area and the NE 124th Street Interchange. North of the BNSF right-of-way, surface flows congregate in roadside ditches flowing north. Runoff draining to the west side of the freeway mainline congregate in ramp median areas where they are conveyed via pipes and ditches to an engineered detention facility located in the southbound ramp median area at the NE 124th Street interchange. Runoff draining to the east side of the freeway along this stretch collect in the wetland complex and pass under the freeway mainline through twin 42 inch culverts located at project station 4251 (milepost 20.5). Runoff from the area north of the NE 124th Street interchange collects in roadside ditches flowing south to the wetland complex, then west to Juanita Creek.

TDA-D2 collects runoff in roadside ditches from areas on-site and offsite to the east and drains to a closed roadway conveyance system crossing under the freeway, then discharges to a small tributary to Juanita Creek at the NE 132nd Street/116th Ave NE intersection, then flows northwest through a forested ravine to converge with Juanita Creek approximately 1-mile west.

TDA-D3 collects runoff from on-site and offsite areas to the east and drains to roadside ditches on both sides of the freeway and within a large median area separating the north and southbound lanes. Runoff collecting in these ditches flows toward a low point at project station 4291 (milepost 21.2), and crosses the freeway through one of two 18 inch culverts. The southern-most culvert discharges to a detention pond facility, which in turn discharges to a small stream running west to converge with Juanita Creek. The northern culvert collects basin flows from the north and conveys directly to a small stream flowing approximately 800 feet northwest to Juanita Creek.

TDA-D4 collects runoff from on-site and off-site areas to the east of the corridor and drains through a series of closed pipes and open ditches to Juanita Creek. These drains parallel the freeway for about 600 feet in a westerly direction.

TDA-E1 collects runoff from on-site and off-site areas to the east and drains through a series of closed pipes and open ditches to Juanita Creek that crosses I-405 in a 48 inch CMP culvert located at project station 4328 (milepost 21.8). This is the main stem of Juanita Creek which continues west and then south though residential neighborhoods.

TDA-E2 collects runoff from on-site and off-site areas to the east and drains through a series of pipes and ditches flowing south and west, discharging to a wetland. The wetland is located on a wedge shaped parcel owned by King County between the freeway and Juanita-Woodinville Way NE as part of the Brickyard Park and Ride facility. Water from the wetland drains southwest along the east side of Juanita-Woodinville Way NE connecting with a tributary to Juanita Creek that converges with the main stem approximately ½-mile further along.

TDA-E3 collects runoff from on-site areas and drains via the Juanita-Woodinville Way NE conveyance system, discharging to the wetland and tributary to Juanita Creek noted above.

<u>Sammamish River</u>: This portion of the I405 corridor lies within the Sammamish River watershed and contains four separate Threshold Discharge Areas (TDA-F1, TDA-F2, TDA-F3 and TDA-F4). TDA-F1 encompasses an area of the freeway mainline and portions of the NE 160th Street interchange. Surface water runoff generated in TDA-F1 is collected in ditches along the freeway mainline where it is intercepted in drainage inlets and flows via pipe system to a nearby wetland lying west of the NE 160th Street interchange. Runoff is generated almost completely from roadway surfaces and embankment areas within the WSDOT right-of-way.

Runoff in TDA-F2 is comprised of onsite and offsite surface water flows from surrounding residential and commercially developed neighborhoods. Offsite flows typically enter this TDA via local drainage networks and proceed down slope through the NE 160th Street conveyance system, where it is collected in a detention pond in the southeast quadrant of the NE 160th Street interchange. Runoff from the detention pond subsequently discharges north under NE 160th Street to an open conveyance ditch running north along the freeway corridor.

TDA-F3 collects both onsite runoff and offsite flows from adjacent areas to the east. Freeway runoff is collected in open ditches and closed conveyance systems that route runoff under the freeway via cross drains, discharging to a ravine beginning at the northwest quadrant of the NE

160th Street interchange. Offsite flows intercept the basin north of the NE 160th interchange in open conveyance ditches that congregate just north of the interchange, then parallel the northbound onramp heading north, then entering a 42 CMP cross drain (project station 4372, milepost 22.7) running west to the head of the ravine. Continuing north, runoff from other offsite areas to the east flows to the freeway ditch system where it is conveyed at intervals under the freeway to discharge to the ravine. The ravine parallels the western edge of the freeway for approximately 1000 feet before veering off to the northwest down slope toward the Sammamish River.

TDA-F4 encompasses an area of freeway corridor that traverses the surrounding terrain sloping north and west to the Sammamish River. Runoff consists of onsite and offsite surface and subterranean flows from the adjacent steep slopes to the east. Runoff from the southern portions of TDA-F4 is collected in ditches and closed pipe conveyance systems and discharged to the ravine lying west. Northern portions of TDA-F4 flow north, down slope through the freeway drainage system to an outfall at the Sammamish River. Cut into the adjacent bluff along the east side of freeway is a drainage berm to intercept surface flows running down the steeply graded slope. Two inlets are spaced behind the berm to collect runoff and convey it to the freeway drainage system, then west down slope to converge with the City of Bothell's drainage system along Riverside Drive. WSDOT maintenance and City of Bothell indicate that this line does not appear to be functioning at Riverside Drive; reportedly filled with sediment or perhaps ruptured. Freeway runoff is thought to bypass this filled catch basin in the freeway shoulder and continue down slope north to the Sammamish River outfall.

TDAs F3 and F4 encompass a portion of freeway that is benched into the side slope of a ridge as it traverses downhill north toward the Sammamish River. Paralleling the freeway on the western side is the previously mentioned steep, vegetated and mostly undeveloped ravine running down slope north toward the river and diverging slightly west from the freeway alignment. A small stream, designated KL-14 in the project "Fish and Aquatic Resources Discipline Report" (included as Appendix C) runs along the bottom of this ravine. Highly erosive storm flows from developed areas upstream have contributed to deteriorating conditions in the stream channel, including deep incision of the stream bed, heavy erosion and migration of bed and bank material, and instability of the associated freeway embankments. Of particular concern are two areas of instability along the freeway encroaching on the western edge of the southbound mainline, including areas proposed for pavement widening in the Nickel project.

Near Riverside Drive, the ravine opens to the Sammamish River flood plain where the stream becomes a shallow braided conveyance through wooded and intermittent wetland areas. The stream is characterized by meanders and apparently frequent channel shifting (by human activity and natural processes) through this stretch as it makes its way to Riverside Drive. At Riverside Drive, the stream enters the roadside ditch where it runs west for approximately 50 feet to enter a catch basin structure and associated 18 inch cross culvert crossing north through the right-of-way. From the north side of the right-of-way, the stream continues north for approximately 200 feet, following the property line in a concrete channel to a steep slide outfall at the Sammamish River.

2.3.2.2 OUTFALL DESCRIPTIONS

Proposed drainage facilities for the Kirkland Nickel project will utilize existing drainage systems and outfalls to the maximum extent practicable. Cross culverts that will be replaced by Nickel improvements will be analyzed for capacity and sized to mitigate any potential upstream flooding. Outfalls for offsite runoff will be maintained at their present location or modified when impacted by freeway alignment changes. City owned storm drain systems will be coordinated with onsite drainage improvements, and when impacted, adjustments will be made in accordance with local jurisdictional standards and input.

Freeway runoff will concentrate at eighteen locations in relation to the individual threshold discharge areas identified for the Kirkland segment. Table 2.3 lists each threshold discharge area and the associated outfall information.

2.3.2.3 OUTFALL SUMMARY TABLE

Table 2.2 provides a summary of proposed treatment facility outfalls for the associated threshold discharge areas. The table includes each of the proposed detention facilities along with specific information about location, facility type and discharge elements. The design build contractor has the option to revise the proposed facilities and their associated discharge points provided that the requirements of the HRM and project design criteria are met.

Table 2.2 Threshold Discharge Area - Outfall Summary Table

Outfall I.D.	Station (milepost)	Facility	TDA	Outfall to
1	4008+20 NB (15.87)	Pond A1	A1	Existing ditch to Yarrow Creek
2	4052+70 NB (16.71)	Vault A2	A2	Existing storm drainage system
3	4131+50 NB (18.20)	Pond B4	B4	Existing storm drainage system
4	4182+00 NB (19.16)	Pond C	C	Existing roadside ditch
5	4197+20 NB (19.45)	Vault C	C	Existing storm drainage system
6	4237+00 NB (20.20)	Pond D1	D1	Existing roadside ditch
7	4294+00 NB (21.28)	Pond D3&4 Combined	D3&D4	Existing ditch to Juanita Creek
8	4327+20 NB (21.90)	Pond E1	E1	Juanita Creek
9	4343+80 NB (22.22)	Pond E2	E2	Existing ditch and wetland
10	4364+00 NB (22.60)	Pond F1	F1	Existing storm drainage system
11	Riverside Dr. W. side of I-405 4400+00NB +850 FT TO WEST (23.28)	Pond F3&4 Combined	F3&F4	Existing roadside ditch leading to Stream KL-14 and the Sammamish River

2.3.3 CULVERTS AND CROSS-DRAINS

2.3.3.1 EXISTING

There are 43 cross-drains and culverts on the Kirkland Nickel project which carry both offsite flow and project stormwater across the WSDOT right-of-way. Except for a single collapsed cross drain at the NE 160th Street interchange, WSDOT maintenance staff report no deficiencies to the existing cross drains within the project limits. Table 2.3 lists the known cross drains along the Kirkland segment and any expected impacts resulting from the Kirkland Nickel project.

2.3.3.2 PROPOSED

Five existing culverts are currently proposed for replacement or modification along the Kirkland alignment. One of these culverts is targeted for modifications to include fish passage (Forbes Creek). Section 2.3.3.3 “Fish Passage Improvements” provides a discussion and additional detailed information for the replacement of this culvert. Other culvert replacements across the I-405 mainline associated with this project includes capacity improvements at station 4101 (milepost 15.95) to connect with Pond A1, Forbes Creek tributary culvert (station 4205, MP 19.59), capacity improvements at NE 116th Street interchange (station 4218, MP 19.83), and replacement of a damaged culvert at NE 160th Street (station 4364, MP 22.60). No new cross culverts will be constructed for the Kirkland Nickel Project.

Other cross culvert improvements anticipated for the Kirkland segment include extension of existing culverts to accommodate roadway widening, addition of new catch basin structures, adjustment of existing catch basin and inlet structures, removal of culvert sections and related drainage structures, replacement of existing culverts and related structures, headwall construction to limit sensitive riparian zone impacts, and outfall stabilization techniques at the culvert ends. Anticipated improvements are indicated on Table 2.3 below.

New impervious surface areas proposed for the Kirkland Nickel project are relatively small in most areas of the project and will contribute little in the way of additional flow. Capacity impacts to the individual culverts are considered negligible because of the small flow increase and the extended hydro period of the related ecology embankments which will attenuate flows by slowing the progress of runoff and providing detention capacity in the media filter and associated underdrain system.

Table 2.3 Kirkland Cross Culvert Systems and Expected Impacts

Culvert ID	TDA Basin	Culvert Type	Station (MP)	Extend Culvert	Add CB(s)	Adjust CB	Remove	Replace	Fish Pasg	Head Wall	Outfall Protect	No Impact	Notes
1	A1	Unk	4101 (15.95)		W,E			190’					1
2	A1	18" conc	4019 (16.07)	13'W	W		W						
3	A1	18" conc	4025 (16.18)	15'W	W	W							
4	A1	18" conc	4032 (16.32)	13'W	W								
5	A1	24" conc	4040 (16.47)	16'W	W								
6	A1	18" conc	4042 (16.51)	16'W	W								
7	A1	Unk	4045 (16.55)	15'W	W								
8	A2	Unk	4052 (16.70)										2

Culvert ID	TDA Basin	Culvert Type	Station (MP)	Extend Culvert	Add CB(s)	Adjust CB	Remove	Replace	Fish Pasg	Head Wall	Outfall Protect	No Impact	Notes
9	B1	unk	4070 (17.05)			Median							
10	B1	Unk	4080 (17.23)			Median							
11	B2	Unk	4085 (17.32)				W,E						
12	B2	Unk	4097 (17.54)									X	
13	B2	Unk	4099 (17.58)									X	
14	B2	Unk	4111 (17.82)			Median							
15	B2	Unk	4131 (18.20)			E							
16	C1	12" cmp	4151 (18.57)	20'W 15'E						E	W,E		
17	C1	24" cmp	4163 (18.79)	22'W	W		CB West						
18	C1	18" cmp	4172 (18.96)	25'W			CB West			E	W, E		
19	C1	24" conc	4177 (19.07)	20’W									
20	C1	36" cmp	4181 (19.14)					490’	X				3
21	C1	24" cmp	4196 (19.42)					330’					4
22	C1	24" cmp	4205 (19.59)		E, W, M			292'					5
23	C1	24" DI	4218 (19.83)		X		X	X					6
24	D1	(2) 42"	4251 (20.46)									X	7
25	D2	54" cmp	4272 (20.86)									X	8
26	D3	18" conc	4278 (20.97)									X	
27	D3	24" cmp	4291 (21.23)	20' Median	Median					E	E		9
28	D3	30" cmp	4294 (21.27)	30' Median	Median					E	W, E		10
29	D3	30" cmp	4301 (21.41)	35' Median	Median		2-CBs E			E	Median		11
30	D4	18" cmp	4308 (21.54)			Median							12
31	D4	18" cmp	4315 (21.67)									X	

Culvert ID	TDA Basin	Culvert Type	Station (MP)	Extend Culvert	Add CB(s)	Adjust CB	Remove	Replace	Fish Pasg	Head Wall	Outfall Protect	No Impact	Notes
32	E1	48" cmp	4328 (21.92)									X	13
33	E1	24" conc	4337 (22.10)									X	
34	E2	18" conc	4347 (22.28)	72' W	(2) West		CB West						
35	F1	24" conc	4364 (22.60)		(3) W (2) E			152'					14
36	F3	42" cmp	4372 (22.75)									X	15
37	F3	24”	4377 (22.84)		W, E		CB West						16
38	F3	18" cmp	4380 (22.90)		W, E		CB West						17
39	F3	18" cmp	4384 (22.98)		W, E								18
40	F3	18" conc	4392 (23.13)		W, E		CB West						19
41	F4	18" conc	4395 (23.18)		W, E								20
42	F4	30" cmp	4396 (23.20)									X	
43	F4	24" conc	4404 (23.35)		E								21

1. Replace existing culvert
2. Connect to proposed detention vault
3. Forbes Creek main stem; construct new fish passage culvert; riparian zones east and west
4. Forbes Creek tributary; riparian zone east side
5. Forbes Creek tributary; riparian zone east side
6. Replace/upgrade existing NE 116th Street drainage system
7. Juanita Creek / Totem Lake tributary
8. Juanita Creek tributary
9. Discharge to existing detention pond, west side
10. Reconstruct outfall to Juanita Creek tributary; riparian zones west and east sides
11. Juanita Creek tributary; riparian zones east and west sides
12. Address flooding issues on west side right-of-way, improve ditch and catch basin structure
13. Juanita Creek main stem; do not impact culvert or riparian area
14. Construct new cross drainage, abandon existing damaged culvert
15. Unnamed Creek tributary to Sammamish River
16. Construct on-site and off-site bypass systems
17. Construct on-site and off-site bypass systems
18. Construct on-site and off-site bypass systems
19. Construct on-site and off-site bypass systems
20. Construct on-site and off-site bypass systems
21. Construct flow splitter and drainage system to Sammamish River outfalls

2.3.3.3 FISH PASSAGE IMPROVEMENTS

The Kirkland Nickel project will provide fish passage improvements at the I-405 crossing of Forbes Creek. The proposed fish passage improvements consist of a new 78 inch diameter culvert and fishway facility. The proposed culvert alignment is parallel to the existing 42 inch diameter Forbes Creek CMP culvert under I-405. The 78 inch culvert has been designed to meet Washington Department of Fish and Wildlife (WDFW) fish passage requirements up to 18 cfs, the maximum fish passage flow. Flows above this threshold will be conveyed by both the existing and proposed culverts under I-405.

Discharge from the proposed culvert will be routed into the first active pool of the fishway. Flows up to 18 cfs will be conveyed through the fishway. Flows above the 18 cfs will be overtop a broad crested weir at the first active pool and conveyed back into the stream channel. Flows over 18 cfs being routed through the existing 42 inch culvert will be discharged into the stream in the same manner as they are today.

Appendix E of this report contains current plans, calculations, and technical data summary used to design the fish passage facilities.

2.3.4 BRIDGES

2.3.4.1 EXISTING

Four existing bridge structures are situated along the Kirkland segment of I-405. Except for the BNSF railroad structure, the bridges are typically part of the freeway interchange system connecting with local surface streets. No bridge structure has been constructed along the Kirkland segment to span a stream or river conveyance. Table 2.4 lists the I-405 mainline bridge structures for the Kirkland segment and the associated conveyance system.

Table 2.4 Existing Mainline Bridge Structures for Kirkland Nickel Segment

Bridge Structure	Mile Post	Conveyance
NE 85th Street	18.14 Sta 4126	Drainage network; all quadrants of interchange; converge to flow west along NE 185th Street
NE 116th Street	19.86 Sta 4118	NE 116th St conveyance system; 24-inch D.I. pipe flowing west to converge with Forbes Ck. Tributary
BNSF Railroad	20.04 Sta 4226	Open ditch conveyance both sides of railroad tracks; flowing east toward Totem Lake
NE 132nd Street	20.93 Sta 4274	NE 132nd Street conveyance system; converges at west side with Juanita Ck tributary flowing west

2.3.4.2 PROPOSED

Two new bridges are proposed for the Kirkland Nickel project. The I-405 bridge over NE 116th Street will be reconstructed at the Implementation Plan horizontal and vertical location. The bridge will be built to Nickel width and require widening to complete the mainline Implementation Plan. The bridge over BNSF railroad will also be reconstructed to match freeway profile changes at the NE 116th Street bridge and to meet Implementation stage configurations.

The NE 116th Street drainage system will be reconstructed with the proposed interchange improvements to address pipe capacity and related flooding concerns in the localized depression under the bridge structure. Drainage ditches along the railroad right-of-way will be maintained or adjusted to function as before.

3 DRAINAGE CRITERIA

Design criteria for storm water management is included in the Stormwater Design Criteria Technical Memorandum dated May 18, 2004. This document outlines stormwater design criteria for all I-405 corridor Nickel projects, and is included with this report as Appendix C.

Stormwater management facilities for the Kirkland Nickel Project have been designed predominantly to comply with the following guidelines and procedures:

- WSDOT Highway Runoff Manual M 31-16, March 2004 (HRM)
- WSDOT Hydraulics Manual M 23-03, March 2004

In most cases, these documents require runoff treatment and flow control for 100 percent of new impervious surfaces. Designs of storm drainage improvements for the Kirkland Nickel Project will utilize the most recent version of the WSDOT Highway Runoff Manual (2004) (HRM) as the primary design reference. In rare instances, where the new HRM is in conflict with the Washington State Department of Ecology Stormwater Management Manual for Western Washington (2001) (SMMWW), clarification from the I-405 project team will be sought to resolve differences in design criteria between the two documents.

For the Kirkland Nickel project, specific differences have previously been encountered between the two reference documents. In these instances, the I-405 project team has coordinated between the WSDOT Hydraulics Department and the Washington Department of Ecology hydraulics group to work out design criteria that assures compliance and streamlined permitting. Resolution of these issues is documented in design decision papers, included in this report in Appendix D. Specifically, these documents address the following Stormwater Design Decisions:

- Forested vs. Existing Pre-development Condition; Kirkland Nickel Project, June 14, 2004: Outlines the decision to use forested land cover as the predeveloped condition for designing detention systems within the Kirkland Nickel Project
- Infiltration Investigations; Kirkland Nickel Project, July 15, 2004: documents the decision to use a concept level geotechnical investigation procedure for determining stormwater infiltration rates within the Kirkland Nickel Project
- Treatment of Runoff from New Impervious Surfaces; Kirkland Nickel Project, July 23, 2004: provides a discussion and definitions of “new”, “replaced” and “effective” impervious surfaces for the purposes of determining and calculating minimum treatment requirements for storm water runoff within the Kirkland Nickel Project

Additional design references and guidelines have been used as they apply for local jurisdictional requirements. Coordination activities are ongoing with City of Kirkland and other city and county officials from along the corridor segment. The intent is to address specific local concerns regarding integration of new storm drainage and utility improvements and to provide solutions that work to the mutual benefit of each stakeholder.

4 STORMWATER TREATMENT

4.1 APPROACH AND DESCRIPTION

The basic approach for design of storm drainage improvements for the Kirkland segment is to utilize as much of the existing drainage system as possible. Integration of new systems and treatment facilities will require minor adjustments in most cases to localized portions of the existing storm systems. Where possible, associated freeway runoff will be isolated and treated separately from offsite stormwater to reduce the size of the associated treatment facilities.

Where circumstances permit, it is sometimes beneficial to provide runoff treatment at offsite locations by applying watershed scale improvements. The principle concept is to apply treatment and conveyance measures that enhance flow control and/or water quality conditions for the watershed while meeting the standards of stormwater design for freeway development. This approach is more attractive when standard treatment applications are difficult or expensive to construct within the freeway right-of-way.

In addition to providing enhanced treatment for the new pavement areas, 43.4 acres of presently untreated impervious surface will be retrofitted for enhanced runoff treatment. The additional treatment is primarily due to the nature of the roadway improvements. The Kirkland Nickel project will typically add new pavement along the outside edge of the existing freeway pavement. Through coordination with Washington State Department of Ecology, it was determined that runoff treatment measures (primarily in the form of Ecology Embankments) would be applied for all areas of new pavement where possible. Design of runoff treatment BMPs requires that treatment be provided for all new pavement and for any existing pavement that drains over the new pavement (Effective Impervious Surface). In total, runoff treatment will be provided for approximately 356% more area than what is required for the new pavement only. A summary of runoff treatment applications and associated areas is included in Table 4.2.

Runoff treatment will be provided in accordance with the WSDOT Highway Runoff Manual in the form of ecology embankments, combined treatment trains, and constructed stormwater treatment wetlands. Ecology embankments are the preferred method of runoff treatment because of their flexibility in construction, enhanced treatment capabilities, relative low cost and ability to fit within a narrow right-of-way.

Stormwater flow control will be provided for a total of 16.1 acres of new pavement project-wide, which is greater than the total net new pavement area of 13.6 acres. Where required, flow control will be provided in accordance with the HRM in the form of detention/retention ponds and detention vaults. Infiltration will be used whenever possible to discharge stormwater or otherwise reduce flow control treatment volumes. It will be the Design-Builder’s responsibility to perform the necessary geotechnical investigations and testing to define the locations and rates for incorporating infiltration into the final design.

Existing drainage structures and systems will be retained in the Kirkland section as much as practicable. New structures will be added, as needed, to incorporate treatment facilities or fix existing drainage problems. Typically, proposed collection and conveyance systems will consist of standard WSDOT catch basin and manhole structures connected by lateral and trunk drains to the treatment and detention facilities. Pipe sizes will generally range from 12 to 30 inches in diameter and be installed on grades and at depths necessary for proper clearances and hydraulic performance. Inlets are placed at locations necessary to limit the spread of design flows into the travel lanes, as required by the *WSDOT Hydraulics Manual*.

For the Kirkland Nickel project, only the new pavement stormwater is required to be treated. Except for a few areas where the existing pavement runoff mixes in with new pavement runoff, the existing pavement will not be retrofitted for treatment of stormwater runoff. This is planned to be done later, during the next phase (Implementation Phase) of the I-405 Corridor project. Wherever possible, the new pavement storm runoff will be first treated by filtering the runoff sheet flow through an ecology embankment (enhanced filter media) built into the embankment below the outer edge of the freeway shoulder. Treated runoff is collected from the ecology embankment by an underdrain pipe constructed beneath the facility and discharges into paralleling ditch or pipe conveyance systems.

Storm water from the new pavement areas will be detained on-site and released back to the existing flow path at a rate that matches pre-development land cover condition. Flow control volumes will be provided by either ponds or underground vaults, or combined with rock-filled infiltration trenches. Where it is not feasible to install conveyance and treatment systems for new pavement areas, equivalent areas of existing pavement within the same TDA are treated for an equivalent effect, as specified in the HRM.

Open ditches along the edges of the shoulders are the preferred collection system since they often provide additional sediment deposition, flow control capacity, and vegetative filtration type runoff treatment of pavement storm water. Existing ditches that are displaced due to project widening of the pavement prism will be replaced where right-of-way and grading conditions allow.

4.2 APPLICABLE BEST MANAGEMENT PRACTICES (BMP)

4.2.1 FLOW CONTROL TREATMENT

Flow control treatment of stormwater will be applied according to the WSDOT Highway Runoff Manual (HRM). BMP facilities are selected from the HRM and sized appropriately for each affected threshold discharge area and their associated areas of new impervious surface. These facilities may include stormwater detention/infiltration ponds, stormwater detention/infiltration vaults, infiltration trenches, and combined detention wetland facilities. Selected flow control BMPs and associated information for each affected threshold discharge area (TDA) is listed in Table 4.1 Summary Table for Flow Control Treatment. See the drainage maps in Appendix A for the location of each TDA and the associated flow control facilities.

4.2.2 RUNOFF TREATMENT

Runoff treatment of highway stormwater will be applied according to the HRM. BMP facilities are selected from the HRM and sized appropriately for each affected threshold discharge area and their associated areas of new pavement. These BMPs may include ecology embankments, constructed stormwater treatment wetlands and wetponds, low impact development (LID) type BMPs, filter strips and swales and other innovative use of the BMPs outlined in the HRM. Selected runoff treatment facilities and associated information for each affected threshold discharge area are listed in Table 4.2 Summary Table for Runoff Treatment. See the drainage maps in Appendix A for the location of each TDA and the associated treatment facilities. The use of sand filters or any proprietary BMPs shall require written approval from WSDOT before used in design as these BMPs are maintenance intensive.

4.2.3 TREATMENT SUMMARY TABLES

Table 4.1 provides a summary of proposed flow control facilities in the Kirkland segment. The table includes each of the proposed detention facilities for the Kirkland Nickel segment along with specific information about location, contributing surface areas, and facility dimensions. The facilities listed in the table are provided as a possible solution to meeting the flow control requirements within each respective threshold discharge area. The design build contractor has the option to revise the proposed facilities provided that the requirements of the HRM and project design criteria are met.

Table 4.1 Summary Table for Runoff Flow Control Treatment

Facility I.D.	Station (Milepost)	Net New Pvmt (ac)	Contributing Area (ac)	Facility Type	Depth (ft)	Area (sf)	**Vol (ac-ft)***
A1	4011 (15.93)	1.08	1.08	Pond	5.0	8,433	**0.68**
A2	4052 (16.71)	0.44	0.44	Vault	5.0	2,405	**0.28**
B4	4132 (18.21)	0.35	0.35	Pond	4.0	3,873	**0.23**
C1.1	4175 (19.01)	7.92	1.66	Pond	5.0	12,008	**1.02**
C1.2	4195 (19.40)		7.95	Vault	10.0	20,032	**4.60**
D1	4235 (20.16)	0.57	0.75	Pond	2.5	8,712	**0.50**
D3/D4	4291 (21.20)	1.00	1.00	Expand Pond	4.0	6,534	**0.60**
E1	4331 (22.00)	0.83	0.83	Pond	3.0	11,352	**0.65**
E2	4345 (22.25)	0.32	0.97	Pond	3.0	13,046	**0.76**
F1	4362 (22.57)	0.20	0.23	Pond	4.0	2,736	**0.15**
F3/F4	4400 (23.25)	0.79	13.98	Comb. Pond	+/- 4.0	5,600	**0.64**
				Detention Total			**10.14**

Note: Shaded Cells indicate facilities constructed in Stage 1

* Flow control volumes assume no infiltration

Table 4.2 provides a summary of proposed runoff treatment facilities in the Kirkland Nickel project. The table includes each of the proposed water quality facilities along with specific information about location, contributing surface areas, and facility dimensions. The facilities listed in the table are provided as a possible solution to meeting the enhanced runoff treatment requirements within each respective threshold discharge area. The design build contractor has the option to revise the proposed facilities provided that the requirements of the HRM and project design criteria are met.

Table 4.2 Summary Table for Pavement Runoff Treatment

Basin Name	Facility I.D.	Sta to Sta (MP to MP)	Contributing EIS Area (ac)	New Pavement Area (ac)	% Treatment of Pavement Area	Facility Type	Facility Length (ft)	Facility Size Area (sf) *
A1	A1.1	4013 - 4027 (15.89 - 16.22)	1.11	1.08	193%	Ecology Embkmt	1755	5750
A1	A1.2	4030 - 4045 (16.28 - 16.57)	0.97			Ecology Embkmt	1541	6164
A2	A2.1	4045 - 4052 (16.57 - 16.69)	0.73	0.44	316%	Ecology Embkmt	633	2532
A2	A2.2	4053 - 4060 (16.83 - 16.84)	0.66			Ecology Embkmt	579	2300
B4	B4.1	4130 - 4134 (18.16 - 18.25)	1.28	0.35	863%	Ecology Embkmt	466	1864
B4	B4.2	4138 - 4151 (18.34 - 18.58)	1.74			Ecology Embkmt	1245	4980
C1	C1.1	4151 - 4192 (18.58 - 19.36)	8.23	9.61	130%	Ecology Embkmt	4111	16444
C1	C1.2	4179 - 4205 (19.10 - 19.67)	4.24			Ecology Embkmt	2584	10336
D1	D1.1	4219 - 4224 (19.85 - 19.90)	3.69	0.75	492%	Ecology Embkmt	490	2450
D3	D3.1	4281 - 4301 (21.06 - 21.40)	3.50	0.53	660%	Ecology Embkmt	1790	7160
D4	D4.1	4301 - 4310 (21.07 - 21.57)	1.85	0.47	664%	Ecology Embkmt	1533	6132
D4	D4.2	4305 - 4320 (21.48 - 21.77)	1.27			Ecology Embkmt	815	3260
E1	E1.1	4320 - 4342 (21.77 -	2.99	0.83	360%	Ecology Embkmt	2080	8320

Basin Name	Facility I.D.	Sta to Sta (MP to MP)	Contributing EIS Area (ac)	New Pavement Area (ac)	% Treatment of Pavement Area	Facility Type	Facility Length (ft)	Facility Size Area (sf) *
		22.18)						
E2	E2.1	4342 - 4357 (22.17 - 22.46)	2.41	0.97	413%	Ecology Embkmt	1496	5984
E2	E2.2	4349 - 4358 (22.31 - 22.48)	1.60			Ecology Embkmt	900	3600
F1	F1.1	4358 - 4364 (22.48 - 22.60)	1.48	0.23	643%	Ecology Embkmt	680	2720
F3/4	F3/4	4400 (23.25)	13.98	0.79	1770%	Comb. Wetland	NA	1343
Water Quality Totals			**51.73 ac**	**16.05 ac**	**322%**			**91,339**

* For ecology embankments, facility size calculated as length of ecology embankment multiplied by 4-feet (min. embankment width)

4.2.4 PROPOSED DRAINAGE FACILITIES

New collection facilities will be placed where required, typically outside of the new shoulder pavement areas, with runoff contained and rerouted to new treatment facilities. In portions of the Kirkland segment new drainage structures will be added in conjunction with roadside curbing to isolate freeway runoff from off-site runoff.

Enhanced runoff treatment will be provided for the freeway storm water. The predominant treatment measure expected to be used is a filtration method, utilizing an amended media and underdrain type filtration system located within the roadway embankment or median shoulder collection ditches. This BMP is the “ecology embankment” (or “double ecology embankment” when built as a ditch section) as defined in the WSDOT Highway Runoff Manual (HRM). Other runoff treatment BMPs that may be applicable for this project are constructed stormwater treatment wetland facilities, and HRM standard two-facility treatment trains that would be constructed where the ecology embankment may not be feasible. Chapter 5 of the HRM lists a selection of possible enhanced water quality treatment BMPs that may be used for the Kirkland Nickel project. The goal is to minimize large isolated treatment facilities and maintain the existing drainage patterns within each drainage basin for the Kirkland Nickel project. The use of sand filters or any proprietary BMPs shall require written approval from WSDOT before use in design as these BMPs are maintenance intensive.

Infiltration will be utilized wherever possible; however, in most cases flow control detention must be provided as well. Detention is proposed through the use of open ponds and concrete vaults. Vaults and ponds will be sized and constructed per the Nickel project footprint. Where possible, they have been located to work with, and be part of the future implementation stages of construction. Drainage systems have been laid-out to help minimize disruption of existing pavement and traffic since much of the existing highway pavement is to be maintained for this first phase of the Kirkland section improvements.

Drainage design concepts have been advanced to include enough detail as to represent solutions that are constructible and permitable. These design concepts will be further refined by the design-build team, who will prepare final construction plans and details for the project.

<u>Threshold Discharge Area A1:</u> A detention pond will be constructed at station 4011 (MP 15.93) along the east side of the corridor that discharges to the roadside ditch at 116th Avenue NE running south to Yarrow Creek. The pond location has been coordinated to function with projected Implementation phase improvements. The detention pond will be constructed within the right-of-way between the freeway mainline and 116th Avenue NE in an existing open area adjacent to the Yarrow Creek buffer zone. The pond will have a depth of 5 feet, with 3:1 side slopes, and a total area of 8,433 square feet. The pond will discharge through an orifice flow control structure and associated 18 inch diameter buried pipe that extends 75 feet on an average grade of 0.02-ft/ft to the southeast (see drainage map in Appendix A for location) to the roadside ditch at 116th Avenue NE. It is expected the discharge end will be protected with rock riprap to avoid erosion of the ditch.

The detention pond provides flow control for an equivalent area, equal to the new pavement area in TDA-A1. The pond collects flows from the ecology embankments using new open roadside ditches that parallel the new project highway shoulders along the west side of the highway between station 4012 to station 4045 (MP 15.95 to MP 16.55). Enhanced runoff treatment will be provided by ecology embankments built into the west side of the freeway embankment adjacent to the new pavement areas between station 4012 to station 4045 (MP 15.95 to MP 16.55). The ecology embankments treat the new widened pavement strip (1.10 acres), plus the existing contributing impervious pavement area (0.98 acres) to the outside of the southbound lanes center crown.

<u>Threshold Discharge Area A2:</u> A detention vault will be constructed at station 4052 (MP 16.71) along the west side of the corridor that discharges west under the noise wall to a local neighborhood drainage network. The discharge point will utilize the existing outfall piping with minor adjustments for connecting to existing infrastructure. The detention vault will be constructed within the right-of-way in an existing open area adjacent to the right-of-way line. It is assumed that this vault will be replaced during Implementation phase development. The open top vault will have a depth of 5-feet, with vertical side slopes, and a total area of 2,405 square feet. The vault will discharge through an orifice flow control structure and associated 18 inch diameter buried pipe that extends 30 feet on an average grade of 0.01-ft/ft to the west (see drainage map in Appendix A for location) to connect with the local neighborhood drainage network. The discharge end will connect with a new catch basin structure installed on the existing City drainage system.

The vault provides flow control for an equivalent area, equal to the new pavement area in TDA-A2. The vault collects flows from the ecology embankments using new conveyance piping that parallel the new project highway shoulders along the west side of the highway between station 4053 to station 4060 (MP 16.71 to MP 16.84). Additional flow is routed from the east side of the freeway through a cross culvert at station 4052 (MP 16.70). Enhanced runoff treatment will be provided by Ecology Embankments built into the west side of the freeway embankment adjacent to the new pavement areas between station 4045 to station 4060 (MP 16.47 to MP 16.84). The ecology embankments treat the new widened pavement strip (0.40 acres), plus the existing contributing impervious pavement area (0.99 acres) to the outside of the southbound lanes center crown.

Threshold Discharge Areas B1, B2 and B3: Repaving activities are scheduled for these TDAs to replace existing shoulder pavement with full depth asphalt. However, no new impervious surface will be constructed in these TDAs for the Kirkland Nickel project and no new stormwater BMPs will be constructed.

Threshold Discharge Area B4: A detention pond will be constructed at station 4132 (MP 18.21) along the east side of the corridor. The detention pond will be constructed within the right-of-way within the northeast quadrant of the NE 85th Street interchange. It is assumed that this pond will be replaced during Implementation phase development. The pond will have a depth of 4 feet, with 3:1 side slopes, and a total area of 3,873 square feet. The pond will discharge through an orifice flow control structure and associated 18 inch diameter buried pipe that extends 20 feet on an average grade of 0.05-ft/ft to the south (see drainage map in Appendix A for location) to connect with existing freeway storm drainage infrastructure. The discharge end will connect to an existing catch basin structure and cross culvert system flowing west under the freeway mainline at station 4131 (MP 18.20).

The detention pond provides flow control for an equivalent area, equal to the new pavement area in TDA-B4. The pond collects flows from ecology embankments using new open roadside ditches and pipe conveyance that parallel the new project highway shoulders along the east side of the highway between station 4130 to station 4139 (MP 18.16 to MP 18.57). Enhanced runoff treatment will be provided by ecology embankments built into the east side of the freeway embankment adjacent to new and existing pavement areas between station 4130 to station 4139 (MP 18.16 to MP 18.57). The ecology embankments treat the new widened pavement strip (0.35 acres), plus the existing contributing impervious pavement area (2.67 acres) to the outside of the northbound lanes center crown.

Threshold Discharge Area C1: Two separate detention facilities will be constructed for flow control treatment in the Forbes Creek basin. A detention pond will be constructed at station 4175 (MP 19.01) along the west side of the corridor that discharges to the existing ditch on the west side of the freeway. Location of the pond has been coordinated to function with projected Implementation phase improvements and will be constructed within the existing right-of-way in an open area west of the southbound lanes. Preliminary geotechnical evaluations indicate that infiltration will not likely be an effective alternative at this location to help reduce pond size.

The pond will have a depth of 5 feet, with 3:1 side slopes, and a total area of 12,008 square feet. The pond will discharge through an orifice flow control structure and associated 18 inch diameter buried pipe that extends 20 feet on an average grade of 0.04-ft/ft to the north (see drainage map in Appendix A for location) to an existing roadside conveyance channel. It is expected that the discharge will be protected with rock riprap to avoid erosion of the channel.

The detention pond provides flow control for an equivalent area, equal to portions of the new pavement area in TDA-C1. The pond collects flows from the ecology embankments using new piping and/or open roadside ditches that parallel the new project highway shoulders along the west side of the highway between station 4151 to station 4179 (MP 18.57 to MP 19.10). Enhanced runoff treatment will be provided by ecology embankments built into the west side of the freeway embankment adjacent to the new pavement areas. The ecology embankments treat the new widened pavement strip (1.04 acres), plus the existing contributing impervious pavement area (3.90 acres) to the outside of the southbound lanes center crown.

Detention vaults will be constructed at approximate station 4195 (MP 19.40) along the west side of the corridor that discharges west to a Forbes Creek tributary flowing west through the existing drainage network of an industrial area. Location of the vaults has been coordinated to function with projected Implementation phase improvements. The detention vault will be constructed within the existing right-of-way in an open area of the freeway embankment between the mainline and 120th Avenue NE.

Vault sizing for TDA-C1 utilizes the "Off-site Inflow Area Method" to model the contributing area of freeway pavement. A discussion of this method is provided in a design decision report located in Appendix D of this document. The vaults will have a depth of 10 feet, with vertical side slopes, and a total area of approximately 10,500-square feet. The vaults will be connected in series and discharge through an orifice flow control structure and associated 24 inch diameter buried pipe that extends about 80 feet on an approximate average grade of 0.05-ft/ft to the northwest (see drainage map in Appendix A for location) to connect with the Forbes Creek tributary system. It is expected that the discharge will utilize the existing drainage patterns and connect with a new catch basin structure installed on the existing drainage infrastructure, then outfall to the existing channel.

The vaults will provide flow control for an equivalent area, equal to a portion of the new pavement area in TDA-C1. The vaults collect flows from the existing and/or new drainage system using a series of new and existing conveyance piping on both sides of the freeway mainline. Enhanced runoff treatment will be provided by Ecology Embankments built into the west and east side of the freeway embankments adjacent to the new pavement areas. Along the west side, ecology embankments will treat contributing pavement between station 4179 to station 4192 (MP 19.10 to MP 19.36). Along the east side of the freeway, ecology embankments will treat contributing pavement between station 4179 to station 4205 (MP 19.10 to MP 16.60). Ecology embankments treat the new pavement (5.79 acres), plus the existing contributing impervious pavement area (4.33 acres) to the outside of the northbound and southbound lanes center crown.

Threshold Discharge Area D1: A detention pond will be constructed at station 4235 (MP 20.16) along the east side of the corridor. It is assumed that this pond will be replaced during Implementation phase development. The pond will be constructed in the right-of-way within the southeast quadrant of the NE 124th Street interchange, and will have a depth of 2.5 feet, with 3:1 side slopes, and a total area of 8712 square feet. The pond will discharge through an orifice flow control structure and associated 18 inch diameter buried pipe that extends 80 feet on an average grade of 0.02-ft/ft to the north (see drainage map in Appendix A for location) crossing under the northbound on-ramp. The discharge end will outfall to an existing ditch conveyance along the east side of the mainline in the southeast quadrant infield area at station 4237 (MP 20.20).

The detention pond provides flow control for an equivalent area, equal to the new pavement area in TDA-D1. The pond collects flows from the freeway using an existing closed conveyance system and a redeveloped roadside ditch graded into the infield area between station 4229 to station 4233 (MP 20.05 to MP 20.14). Enhanced runoff treatment will be provided by Ecology Embankments built into the west side of the freeway embankment adjacent to new pavement areas between station 4219 to station 4224 (MP 19.86 to MP 19.95) The ecology embankments treat the new pavement area (0.57 acres), plus the existing contributing impervious pavement area (3.12 acres) from the superelevated southbound lanes.

Threshold Discharge Area D2: Ecology embankment will be constructed along the new pavement areas of the southbound center median between stations 4281 and 4283 (MP 21.03 and 21.07) to provide enhanced runoff treatment for the new pavement area. Ecology embankment is not required for this TDA because of the very small area of new impervious surface (2102 square feet). However, as a general rule, ecology embankment is applied to all areas of new impervious surface where feasible. This small area of ecology embankment was calculated as part of TDA-D3. Flow control is not required for this TDA because of the small area of new pavement as provided by the threshold criteria described in Chapter 2-3.6.3 of the HRM.

Threshold Discharge Area D3 and D4: These two TDAs will be combined to receive flow control treatment at a single pond location. This alternative is considered feasible since the two TDAs discharge to the same Juanita Creek tributary very close to the ¼-mile limit used for differentiation of TDAs. Benefits of combining these two TDAs include reduced construction cost by limiting pond development to a single location. To provide flow control treatment for the combined system, an existing detention facility at station 4291 (MP 21.20) will be expanded with adjustments made to the existing flow control structure. Current location of the existing pond is assumed to be functional with projected Implementation Phase improvements. The existing pond has a depth of 4-feet and 3:1 side slopes, which will be matched by the expanded portion. When completed, the expanded portion will add 6,534-square feet of surface area to the existing pond. Associated conveyance features will be adjusted to collect and route runoff to the newly improved/expanded pond. Particularly, the existing cross culvert at station 4291 (MP 20.23) will be extended to the east to accommodate new roadway widening into the median.

Enhanced runoff treatment will be provided by construction of Ecology Embankments built into the freeway median on the east side of the southbound lanes [station 4283 to station 4309 (MP 21.07 to MP 21.57)], and along the west side of the southbound lanes [station 4305 to station 4321 (MP 21.48 to MP 21.77)] adjacent to the new pavement widening areas. The ecology embankments treat the new pavement area (1.0 acres), plus the existing contributing impervious pavement area (6.62 acres) from the superelevated southbound lanes.

Threshold Discharge Area E1: A detention pond will be constructed in newly purchased right-of-way on the west side of the mainline at station 4331 (MP 22.00). Location of the pond has been coordinated to function with projected Implementation phase improvements. The pond will have a depth of 3 feet, with 3:1 side slopes, and a total area of 11,352 square feet. The pond will discharge through an orifice flow control structure and associated 18 inch diameter buried pipe system that extends 300 feet on an average grade of 0.04-ft/ft to the south (see drainage map in Appendix A for location) to discharge at Juanita Creek. It is expected that the discharge will include rock riprap to protect against erosion at the outfall.

The detention pond provides flow control for an equivalent area, equal to the new pavement area in TDA-E1. The pond will collect flows from the freeway using the integral pipe system of the ecology embankment BMPs constructed along the western edge of the mainline between station 4320 to station 4341 (MP 21.77 to MP 22.17). Enhanced water quality treatment will be provided by the ecology embankments to treat all freeway stormwater from the west side of the southbound crown. The ecology embankments treat the new pavement area (0.83 acres), plus the existing contributing impervious pavement area (2.16 acres) from the southbound lanes.

Threshold Discharge Area E2: A detention pond will be constructed in newly purchased right-of-way on the west side at station 4345 (MP 22.25) and located to function with future Implementation stage development. The pond will have a depth of 3 feet, with 3:1 side slopes, and a total area of 13,046 square feet. The pond will discharge through an orifice flow control structure and associated 18 inch diameter buried pipe system that extends 20 feet on an average grade of 0.04-ft/ft to the south (see drainage map in Appendix A for location) to discharge at an existing drainage channel flowing west to a nearby wetland. It is expected that the discharge will be protected by rock riprap at the outlet. Preliminary geotechnical evaluations indicate that infiltration may be an acceptable alternative at this location to help reduce pond size.

The detention pond provides flow control for an equivalent area, equal to the new pavement area in TDA-E2. The pond collects flows from the freeway using the integral pipe system of the ecology embankment BMPs, new closed pipe conveyance systems and existing storm drain infrastructure constructed along the western edge of the mainline. Enhanced runoff treatment will be provided by the ecology embankments and/or double ecology embankments to treat all freeway stormwater from the west side of the southbound lanes. Beginning from the south end, ecology embankments will be constructed on the new freeway embankment along new areas of widened pavement from station 4342 to station 4357 (MP 22.17 to MP 22.46).

Further north, a new southbound on-ramp from the Brickyard Park and Ride will be constructed as part of the Kirkland Nickel project. Ecology embankment will be constructed between the southbound freeway mainline and the new on-ramp to treat both contributing sources from station 4349 to station 4358 (MP 22.31 to MP 22.48). Ecology embankments will treat the new pavement area (0.35 acres), plus the existing contributing impervious pavement area (3.66 acres) from the southbound lanes.

Threshold Discharge Area E3: TDA-E3 encompasses the Brickyard Park and Ride facility and associated areas. No new impervious surface, thus no roadway or storm drainage improvements are proposed for the Kirkland Nickel project in this basin.

Threshold Discharge Area F1: Flow control for TDA-F1 will be provided in a detention pond located in the southeast quadrant of the NE 160th Street interchange at project station 4362 (MP 22.57). It is assumed that the pond will remain functional during Implementation phase development. The pond will have a depth of 4 feet, with 3:1 side slopes, and a total area of 2,736 square feet. The pond will discharge through an orifice flow control structure and associated 18 inch diameter buried pipe system that extends 30-feet on an average grade of 0.02-ft/ft to the north (see drainage map in Appendix A for location) to connect with the existing freeway drainage system. It is expected that the discharge end will be connected at a new catch basin as part of new improvements to an existing cross culvert system.

The detention pond provides flow control for an equivalent area, equal to the new pavement area in TDA-F1. The pond collects flows from the freeway mainline and northbound off-ramp area using existing storm drain infrastructure in conjunction with minor improvements to off-ramp piping and roadside ditches. Regrading of the interchange infield area will be necessary to construct the pond to the required dimensions.

Enhanced runoff treatment will be provided by ecology embankments to treat freeway stormwater from the west side of the southbound lanes. Ecology embankments will be constructed along the new pavement widening areas from station 4357 to station 4364 (MP 22.48 to MP 22.60). Ecology embankments treat the new pavement area (0.20 acres), plus the existing contributing impervious pavement area (1.28 acres) from the southbound lanes.

Threshold Discharge Area F2: TDA-F2 encompasses eastern portions of the NE 160th Street interchange and associated areas. No roadway or storm drainage improvements are proposed for the Kirkland Nickel project in this basin.

Threshold Discharge Area F3 and F4:

Right-of-way will be acquired in the lower ravine area to construct a combined stormwater treatment wetland/detention pond facility as provided by the HRM. Location of the combined facility has been coordinated with Implementation phase construction to either remain in its currently designed configuration, or be expanded as conditions and design efforts dictate. The combined facility will be constructed off-line from the associated KL-14 creek to help mitigate flows, provide runoff treatment of freeway water, and to help preserve habitat in the stream.

The detention pond portion of the combined facility will have a depth of 4 feet, with 3:1 side slopes, and a total area of 5,600 square feet. Preliminary soil exploration in this area indicates moderate potential for infiltration, thus it is possible that the required pond volume may be reduced by discharging a portion of the inflowing runoff to the ground. Stormwater not discharged through infiltration will discharge through an orifice flow control structure and associated 30 inch diameter buried pipe system that extends 20 feet on an average grade of 0.03-ft/ft to the north (see drainage map in Appendix B for location) to discharge in a constructed stormwater wetland treatment facility. It is expected that a stabilized discharge will be constructed in the wetland using bioengineering measures to reduce scour and dissipate energy.

The constructed stormwater wetland treatment facility will be constructed immediately down gradient of the detention facility. The wetland cell will have a surface area of 1343 square feet, an average water depth of 1.5 feet (plus or minus 3 inches) and a maximum depth of 2.5 feet. Configuration of the cell should be irregular in shape (not rectangular) with a distribution of depths as specified in the HRM. Discharge from the wetland will be to a stabilized outfall in the roadside ditch along the west side of Riverside Drive.

4.2.5 OFF-SITE DRAINAGE WORK

The I-405 team has investigated opportunities to integrate stormwater improvements with broader watershed improvements along the Kirkland project corridor. Specifically, the team examined the feasibility of creating off-site stormwater facilities to detain and treat runoff from connected areas within a given watershed rather than constructing awkward and/or expensive applications within the freeway right-of-way. The goal was to create improved stormwater treatment facilities in locations that fit better with natural drainage patterns and that provide greater benefit to the overall watershed and related community. Two possible options were examined.

<u>Forbes Creek Option</u> – the I-405 team examined the prospect of acquiring property to create an off-site stormwater pond while simultaneously daylighting a section of Forbes Creek and removing barriers to fish passage. The intended benefit was to reduce the size and expense of freeway detention facilities (large flow control vaults) by providing detention volume in a near-by off-site pond facility. The pond would be located in the existing Forbes Creek alignment, and the creek would be rerouted around the pond with fish passage improvements to allow the migration of salmon and other species of fish. The pond would be constructed off-line to improve flow control to the creek. Water quality BMPs would be applied to the pond facility to treat runoff from the freeway and a near-by industrial park

Several options were looked at with multiple revisions and adjustments. In the end, the concept was abandoned for the following reasons:

- Need for expensive right-of-way acquisition that offset the savings of vault reduction
- Location of a 72 inch Metro sanitary sewer pipe that would need relocation and made grading options difficult
- Geotechnical complications requiring extensive application of retaining walls, and associated risks with the surrounding residential properties.
- Inability to develop effective fish passage design for reasonable cost limited the environmental benefits available from this project

<u>Sammamish River Option</u> – This portion of the freeway is benched into the side slope of a ridge as it traverses downhill north toward the Sammamish River. Orientation of the freeway corridor with the slope makes traditional methods of flow control and water quality treatment difficult to apply. In addition, a drainage ravine paralleling the freeway along the west side has several past occurrences of instability and erosion, partially due to high peak flows from the developing neighborhoods upstream. Effects of these high flows are mass transport of sediment and localized flooding downstream. Varying portions of the ravine are listed with King County as “Erosion Hazard”, “Landslide Hazard”, and “Seismic Hazard” areas.

Offsite drainage improvements are proposed for the Sammamish River watershed as part of the Kirkland Nickel project. To relieve erosion and embankment destabilization in the drainage ravine, all contributing on-site runoff will be routed around the ravine to a new flow control and runoff treatment facility in the Sammamish River flood plain below. New right-of-way will be acquired in the lower ravine to construct a combined stormwater treatment wetland/detention pond facility to collect and treat freeway runoff only. Flow control will be provided for the new Nickel pavement area while water quality treatment will be provided for the entire segment of freeway. Off-site runoff from the upstream side of the corridor will be kept separate from the freeway runoff and routed down slope through a new bypass line to discharge in the Sammamish River at three existing outfalls.

Associated benefits include improved flow control and water quality treatment, preservation of the freeway embankment, reduction of scour and sediment transport in the drainage ravine, and functionality with future phases of development of I-405 projects.

5 CONVEYANCE SYSTEMS

5.1 EXISTING DRAINAGE SYSTEMS

<u>Lake Washington East / Bellevue North Watershed</u>: Within Basin A, on-site runoff is collected and conveyed through a network of closed pipe systems and open ditches paralleling the freeway. Closed pipe systems distribute runoff at intervals to roadside ditches. The roadside ditches further distribute runoff to an open conveyance system along 116th Avenue NE. Some of this runoff flows to and through an existing wetland situated between the freeway corridor and 116th Avenue NE in the vicinity of milepost 16.0 to 16.3. All runoff eventually converges in Yarrow Creek to continue its path south along the freeway alignment, then west to Lake Washington (see drainage maps in Appendix A).

Beginning at station 4010 (MP 15.90) extending north to approximate station 4050 (confines of TDA-A1) the mainline includes a center crown for both sides of the freeway. Stormwater sheet flows from the center crown to roadside ditches or center line gutter along the median divider. Runoff flowing in the gutter is collected in catch basin structures and typically routed through pipes to the roadside ditches. Runoff flowing in the roadside ditches leaves the corridor in several locations running east through open conveyance or closed pipe systems to Yarrow Creek, or one of its small tributaries. A wooded wetland exists between I-405 and 116th Avenue NE at approximate station 4015 to 4030 (MP 16.00 to 16.27). Along this stretch, freeway runoff flows to this wetland and helps to sustain its present condition.

Freeway runoff in the southbound ditch flows down slope south, crossing to the east at intervals through six cross culverts. Proposed roadway widening takes place along this stretch (west side of the southbound lanes). Associated runoff will be treated for enhanced water quality along this stretch by ecology embankment BMPs and continue to discharge along the existing flow paths. Some reconfiguration of storm drainage will take place at the southern end of the basin to route flows to the proposed detention pond, however runoff will not be diverted from the wetland.

TDA-A2 sheet flows runoff from pavement surfaces to roadside ditches and median gutters. Gutter flow enters catch basin structures and discharges through pipes to roadside ditches. A single cross culvert at station 4052 (MP 16.70) conveys runoff to a discharge location on the west side of the freeway where it exits the corridor under the noise wall, flowing west through an 18 inch CMP pipe. Freeway widening will be along the west side of the southbound lanes. Water quality and flow control treatment BMPs will maintain the existing drainage patterns.

Within Basin B, runoff from the freeway corridor typically discharges west through closed conveyance systems as part of the City of Kirkland drainage network. Freeway runoff from TDA-B1 exits the roadway via sheet flow to roadside ditches and median gutters flowing down slope north. Concentrated flow in the gutter enters catch basins and discharges to the roadside ditches. Two cross culverts convey on-site mixed with off-site runoff from adjacent areas east to the west side of the freeway. Runoff continues down slope west though discrete conveyance channels to be collected in a local City of Kirkland neighborhood drainage network flowing west to Lake Washington approximately 1-mile.

TDA-B2 contains portions of the freeway mainline and the NE 70th Street interchange. Freeway runoff from the southern portions of this TDA sheet flows to roadside ditches and median gutters running down slope north. Off-site runoff from adjacent areas east intercept the freeway along this stretch and combine with freeway runoff, crossing at one of three cross culverts. Runoff from the southern portions of TDA-B2 converges at the southwest quadrant of the NE 70th Street interchange discharging west through closed conveyance systems to a ravine which drains to a nearby wetland complex. Runoff from the western portions of the NE 70th Street interchange also converges at this location. Runoff from the eastern portions of the NE 70th Street interchange continues north along the east side of the freeway in open roadside ditches and closed pipe conveyance systems where it enters an existing detention pond in the right-of-way at approximate station 4096 (MP 17.53). Outflow from the detention pond discharges to a nearby cross culvert at approximate station 4097 (17.54) flowing west to discharge in a ravine running down slope west to the aforementioned wetland complex. The freeway surface north of the NE 70th Street interchange is superelevated with sheet flow to the east-northeast. Runoff from the southbound lanes enters an unpaved median area in the divided highway and an open ditch conveyance. Runoff in the median flows north to a catch basin and the previously mentioned cross culvert.

TDA-B3 continues along the down slope north. Freeway runoff sheet flows to roadside ditches and median gutters. In the southern portions of TDA-B3, the freeway surface transforms from an east trending superelevated section to a west trending superelevated section as it winds its way toward the NE 85th Street interchange. Runoff collects in the divided median ditch and along roadside ditches flowing north. The median ditch in this section flows south, counter to the general slope trend of the freeway, and discharges through a cross culvert at station 4099 (MP 17.58). A roadside ditch along the east edge flows north to a cross culvert at station 4111 (MP 17.82) running under the freeway west, discharging to a roadway drainage ditch along the south side of Kirkland Avenue flowing west to intercept the Slater Street South drainage network. Continuing north, freeway runoff sheet flows west to the freeway embankment and down slope to a ditch along Ohde Avenue, flowing north to connect with the Slater Street South drainage system.

TDA-B4 encompasses portions of the freeway mainline and the NE 85th Street interchange. Runoff from the southern portion of this TDA sheet flows from the superelevated freeway section to the median gutter and north in a closed pipe system to a lateral drain discharging west to an existing stormwater facility in the southwest quadrant of the NE 85th Street interchange. Sheet flow from the southbound lanes discharges directly to the infield area in the southwest quadrant, connecting with the stormwater pond system. Outflow from the pond exits the right-of-way west through pipes and ditch conveyance to converge with the NE 85th Street drainage system flowing west.

The NE 85th Street interchange constitutes the general low point in the TDA from which stormwater is discharged west along the NE 85th Street drainage system. Runoff from the interchange and freeway mainline sheet flows into the low lying depressions between the clover leaf ramp sections. Runoff from the southeast quadrant of the NE 85th Street interchange collects in a depression surrounded by the clover leaf of the northbound on-ramp. A roadside ditch flows north along the eastern edge of the northbound off-ramp to converge with the NE 85th Street drainage system. This ditch conveys runoff from portions of the off-ramp and from adjacent off-site areas east. Both of these systems discharge through closed conveyance to a series of depressions in the northeast quadrant of the interchange. From this point, a cross culvert at station 4131 (MP 18.20) conveys runoff west under the freeway to the northwest quadrant of the interchange, then west along the NE 85th Street system.

Continuing north of the interchange, runoff sheet flows from the freeway to roadside ditches and median gutters flowing south to the interchange. A roadside ditch along the east edge discharges through a culvert to the northeast quadrant of the interchange. Water from the freeway median gutter is collected in catch basins and conveyed in lateral pipes to a closed system along the western edge of the southbound lanes. This closed system flows south to the northwest quadrant of the NE 85th Street interchange where it discharges west along the NE 85th Street system.

Progressing north, freeway runoff sheet flows to roadside ditches and median gutters flowing south. Gutter flows are intercepted by catch basins and conveyed to the west side of the freeway. At NE 90th Street, runoff exits the right-of-way running west in a closed roadway system to eventually converge with the NE 85th Street system flowing west to Lake Washington.

Storm drainage improvements will include a new stormwater detention pond and ecology embankments in the northeast quadrant of the NE 85th Street interchange. No major conveyance improvements are proposed for this TDA. See Appendix B for drainage plans and proposed drainage improvements.

<u>Forbes Creek Watershed</u>: On-site collection and conveyance systems include roadway drainage structures, closed pipe systems, open ditch systems, cross culverts, and major stream conveyance culverts. Eight separate cross culverts exist along the freeway mainline within the Forbes Creek basin. Beginning at the southern end of TDA-C1, freeway runoff sheet flows to roadside ditches and median gutters. Roadway pipe systems convey runoff east to roadside ditches and flow down slope to the north. Along the east side of the freeway at various intervals, runoff releases east to Forbes Lake or to Forbes Creek paralleling the freeway. Runoff discharging along the west side of the freeway runs through an open roadside ditch leading north to a cross culvert at station 4177 (MP 19.07) and associated ravine leading down slope east to Forbes Creek. All runoff discharging east of the freeway eventually converges at the Forbes Creek culvert passing beneath the freeway at approximate station 4181 (MP 19.14).

North of the Forbes Creek culvert, runoff sheet flows from roadway surfaces to roadside ditches or median gutters. Gutter flow is collected in catch basins and closed roadway pipe systems and discharged to roadside ditches. Runoff flowing along the east side of the freeway runs in a ditch leading to a cross culvert at station 4196 (MP 19.42). This culvert is designated a tributary to Forbes Creek. A second Forbes Creek tributary intersects the freeway at station 4205 (MP 19.59), conveying mostly off-site runoff from the east to the west side of the right-of-way. Both of these conveyances congregate on the west side of the freeway right-of-way and continue west through closed pipes and open ditches, through a small industrial development, discharging to the BNSF right-of-way, then flowing south to converge with the main stem of Forbes Creek. Freeway runoff draining to the west side along this stretch is conveyed through a roadside ditch leading to an engineered stormwater pond. Discharge from the stormwater pond converges with the Forbes Creek tributary noted above.

From the northern most regions of TDA-C1, runoff is collected from the freeway mainline and NE 116th Street interchange in roadway drainage structures, closed pipe systems, and roadside ditches. A closed conveyance system runs west under the freeway, along NE 116th Street, and receives runoff from the northerly most surfaces, ramp areas, and the associated drainage basin lying up-slope to the east. West of the freeway mainline, the pipe system turns south along the west side of the southbound on-ramp and parallels the freeway to converge with the Forbes Creek tributary noted above.

Flooding has been observed on several occasions in the NE 116th Street roadway in a localized depression under the freeway bridge structure and the northbound off-ramp. The City of Kirkland has expressed concerns regarding pipe constrictions and leaf clogging in the existing drainage system at NE 116th Street. The existing pipe system is predominately constructed of 24 inch pipe and conveys storm flows from a relatively large basin lying upslope east. Within the I-405 right-of-way, the pipe system discharges through an open ditch and drainage inlet fitted with a grated inlet that frequently experiences leaf and debris clogging during heavy autumn and winter rainfall events. The conveyance system continues west through successive 15 inch and 18 inch pipes for approximately 200 feet before transitioning again to 24 inch pipes. Flooding is believed to be the result of leaf clogging and/or the associated pipe constriction in the attached system.

Storm drainage improvements for Forbes Creek basin include addition of a new stormwater detention pond, detention vaults, and ecology embankment water quality treatment BMPs. Conveyance systems will be adjusted to route flows to and from the treatment facilities and to provide capacity and pipe configuration improvements to the NE 116th Street system. Pipe sizes will be analyzed and upgraded to meet capacity requirements as necessary. See Appendix B for drainage plans and proposed drainage improvements.

<u>Juanita Creek Watershed</u>: Beginning from the south, TDA-D1 is elevated with respect to the surrounding terrain with superelevated roadway section between the NE 116th Avenue Bridge structure and the railroad bridge structure. Surface runoff sheet flows to a closed pipe system in the median shoulder or to a vegetated embankment along the west side. All drainage from this area discharges to ditches lining both sides of the railroad tracks and flows down slope to the east toward Totem Lake.

From the railroad track bridge progressing north, roadway runoff sheet flows to the median shoulder gutters, roadside ditches along the east edge, or a sloping embankment and ditch along the west edge. Runoff releasing to the east side flows north to a depressed area in the ramp median at the NE 124th Street interchange where it collects in a closed conveyance system and is routed to the wetland complex located northeast of the NE 124th Street interchange. Runoff releasing to the west side typically sheet flows down the embankment to a grassed ditch running north. Additional off-site flow from commercial areas to the west converges in this ditch and progress north along the west side of the southbound on-ramp from NE 124th Street. The local roadway conveyance system at 116th Avenue NE and NE 124th Street interchange accepts the runoff at this point and flows north along 116th Avenue NE, discharging to the wetland.

North of the NE 124th Street interchange, runoff sheet flows from roadway surfaces to the median gutters and closed roadway conveyance systems or roadside ditches. Roadway surfaces around the interchange are routed to a detention pond and water quality facilities located in the ramp median at the northeast quadrant of the interchange. These runoff treatment facilities discharge through local roadway conveyance systems to the Totem Lake wetland complex east.

Progressing north, roadway runoff is collected in closed conveyance systems and open roadside ditches and conveyed south to the wetland complex. Runoff releasing east of the freeway is conveyed in a grassed ditch to the wetland complex, then crosses the freeway to the west through twin 42 inch culverts at station 4251 (MP 20.46). Runoff releasing west of the freeway is conveyed south via grassed ditch to a detention facility, then releases to the wetland complex immediately west.

Runoff from TDA-D2 typically drains to a closed conveyance system at the NE 132nd Street underpass. Beginning from the south, runoff from the northbound off-ramp and southbound on-ramp sheet flow to open ditches, then collect in closed pipe conveyance systems. These pipe systems converge with the NE 132nd Street conveyance system flowing west under the freeway and discharge to a small tributary to Juanita Creek beginning at the intersection of NE 132nd Street and 116th Avenue NE. Immediately north of NE 132nd Street interchange, runoff is collected in the freeway median gutter and associated pipe system, or roadside ditches and conveyed to the NE 132nd Street conveyance system.

Progressing north, roadway runoff drains to roadside ditches in the median area and east of the freeway where it is conveyed south, intercepted by an 18 inch cross culvert system at station 4278 (MP 20.97) and routed west through a series of pipes and ditches to the small Juanita Creek tributary near the intersection of NE 132nd Street and 116th Avenue NE. Runoff releasing on the west side of the freeway sheet flows down the freeway embankment to a shallow ditch where it flows south to the Juanita Creek tributary system.

TDA-D3 encompasses an area with divided superelevated roadway draining via sheet flow to roadside ditches in the median area and along the east side of the northbound lanes. These ditches drain to one of three cross culverts running west from the median strip to the western edge of the freeway right-of-way. Flows from the median area approaching from the south are intercepted by a 24 inch CMP cross culvert at station 4291 (MP 20.23) crossing west to an existing stormwater detention pond. Runoff from the east side of the freeway crosses to the median area through twin 18 inch cross culverts. A second cross culvert exists approximately 300-feet north at station 4294 (MP 21.27) to collect flows approaching from the north including those from the twin cross culverts. This 30 inch CMP culvert conveys a small tributary to Juanita Creek which outfalls to a deeply incised and eroded ravine on the west side of the southbound lanes and flowing west through Edith Moulton Park.

TDA-D4 encompasses an area of divided highway corridor with superelevated cross sections at the southern end. Runoff from the superelevated sections sheet flows east to median and roadside ditches where it is conveyed south down slope to a 30 inch cross culvert that lies at station 4301 (MP 21.41); conveying flows from a small Juanita Creek tributary. This system routes water from the eastern shoulder ditch through a 30 inch cross culvert to the median, where it outfalls to a short stretch of open channel flow running west through the median strip. Stream flow enters a catch basin at the east side of the southbound lanes and another 30 inch cross culvert flowing west to discharge at the base of the western freeway embankment. At this point, the runoff enters a local roadway conveyance system of 18 inch pipes and open ditches flowing west along NE 140th Street to converge with Juanita Creek approximately 600 feet down slope.

A second cross drain system exists at station 4308 (MP 21.54) conveying runoff from the east shoulder ditch through a series of 18 inch pipes running west to discharge at the toe of the freeway embankment. An inline catch basin is situated in the median, but this catch basin is fitted with a solid lid and the ditch is graded to prevent collection of surface water. Runoff conveyed in this culvert exits the right-of-way through a residential neighborhood conveyance system to converge with Juanita Creek approximately 500-feet down slope to the west.

Progressing north, a third cross drain system is located at station 4315 (MP 21.67) conveying runoff from the east shoulder ditch through a series of 18 inch pipes running west to discharge at the toe of the freeway embankment. An inline catch basin is situated in the median to collect runoff from the median ditch. This culvert system is located near the top of the basin divide and receives little flow. Runoff is conveyed south along the toe of the freeway embankment for approximately 200 feet before it leaves the right-of-way through a residential neighborhood conveyance system to converge with Juanita Creek approximately 500 feet down slope to the west.

Proposed storm drainage improvements for this TDA include ecology embankments along sections of new pavement, regrading and reconstruction of roadside ditches, and other conveyance improvements to route runoff to the proposed detention pond expansion in TDA-D3. See Appendix B for drainage plans and proposed drainage improvements.

TDA-E1 drains to the main stem of Juanita Creek at a 48 inch culvert crossing located at station 4328 (MP 21.92). This culvert constitutes the outfall to the High Woodlands Detention Facility located in the Juanita Creek ravine east of the freeway mainline. Runoff releasing on the east side of the freeway flows down slope to this flow control facility. Runoff releasing to the west side of the freeway discharges near the culvert outlet on the west side.

Beginning at the south end of TDA-E1, highway runoff is collected in the median shoulder gutter or roadside ditches and conveyed down slope north to converge with Juanita Creek. Runoff releasing to the west side along this stretch of freeway sheet flows down the embankment into the Juanita Creek ravine. Runoff from the median gutter is collected in catch basins and discharged west though a 12 inch lateral drain near the 48 inch Juanita Creek culvert location. Runoff sheet flowing east from the freeway surface is collected in a roadside ditch flowing down slope north to the Juanita Creek ravine and the High Woodlands Detention Facility.

North of the Juanita Creek cross culvert, roadway runoff flows to a sag in the corridor profile at approximate station 4333 (MP 22.01). Median gutters convey surface flows to a series of catch basins and pipes discharging to the east shoulder ditch and a stormwater facility located at approximate station 4336 (MP 22.06). Roadside ditches and closed conveyance piping along the eastern edge also convey freeway runoff to this pond facility. Stormwater discharge from the stormwater facility runs north through a coalescing plate oil/water separator, then north to an open channel conveyance running down slope northeast to a cross culvert located at station 4337 (MP 22.10).

Runoff from the western edge of the freeway is collected by curbing and catch basins and discharged at the western toe of the freeway embankment. A gabion wall has been constructed along the toe of the western freeway embankment, with a shallow conveyance ditch below. The cross culvert and lateral drains from the roadway above discharge though penetrations in the gabion wall. Runoff flows a short distance in this shallow ditch before discharging through inlets to a local neighborhood conveyance system, then southwest to converge with Juanita Creek down slope approximately 500 feet.

Storm drainage improvements for this TDA include ecology embankment construction along the entire western edge pavement widening areas, a new stormwater flow control facility near the sag at the western edge, and conveyance improvements to route runoff to the proposed facilities. See Appendix B for drainage plans and proposed drainage improvements.

Runoff from TDA-E2 collects in closed roadway conveyances and open ditches. Catch basins and lateral discharge pipes are located at intervals along this stretch of freeway discharging to the west. A roadside ditch along the east side collects roadway runoff as well as offsite flows from the east, conveying them down slope to the south. A single 18 inch cross culvert is located at station 4348 (MP 22.28). Runoff from this stretch of freeway discharges west through pipe penetrations in a gabion wall outfalling to a ditch running south along the western edge of the right-of-way. This ditch terminates at approximate station 4344 (MP 22.22) and releases down slope to the west in a shallow channel running to a nearby wetland.

Stormwater improvements for TDA-E2 include ecology embankments along the western edge adjacent to new pavement widening areas and a stormwater detention pond constructed in newly acquired right-of-way west of the freeway mainline. Conveyance improvements will collect and route runoff from existing storm drainage infrastructure through the proposed facilities. See Appendix B for drainage plans and proposed drainage improvements.

TDA-E3 encompasses the area around the Brick Yard Park and Ride and southwest quadrant of the NE 160th Street interchange. Runoff from this area is collected in parking area catch basins and open perimeter ditches and conveyed to a small treatment pond at the southwest corner of the park and ride facility. Runoff from NE 160th Street sheet flows to a curb and gutter, collects in catch basins and flows southwest in the roadway conveyance system for Juanita-Woodinville Way NE. All drainage from this basin is conveyed through this system and discharges to a wetland at the southwest corner of the parcel approximately 900 feet south. Runoff from the wetland consists of stormwater surface flows and subterranean springs which drain to the southwest along a tributary to Juanita Creek running west to converge with the Juanita main stem approximately 1500 feet south. No stormwater improvements are proposed for this TDA in association with the Kirkland Nickel project.

Sammamish River Watershed: TDA-F1 collects runoff from the freeway mainline and the vicinity of the NE 160th Street interchange. Freeway runoff from the western edge sheet flows to a roadside ditch, from where it is conveyed down slope north to collect in catch basins and a related pipe network running along the western edge of the freeway. Runoff collected in the freeway median gutter is likewise collected in catch basin structures and conveyed to the western edge pipe network. Runoff from the eastern side of the freeway mainline sheet flows to a roadside ditch where it joins with runoff from the northbound off-ramp to NE 160th Street interchange and a small quantity of off-site runoff from adjacent areas east. These flows converge in a catch basin near the NE 160th Street bridge structure and a cross culvert at station 4364 (MP22.60). This cross culvert was reportedly damaged during construction for bridge improvements and does not convey runoff at full capacity. Otherwise, flow from this culvert connects with the west side pipe network, then conveyed west through the northwest quadrant of the NE 160th Street interchange and discharges to a wetland just west of the right-of-way.

Runoff generated at the northwestern quadrant of the interchange typically sheet flows to curbs and gutters, then to catch basin inlets and closed pipes, and discharges to a detention facility located at the northwest quadrant of the interchange. Stormwater outflowing from the detention pond joins the freeway runoff at a roadside catch basin and discharges to the wetland.

Storm drainage improvements for TDA-F1 include ecology embankment along new pavement areas on the west side of the southbound lanes and a new flow control pond in the northbound off-ramp infield of NE 160th Street interchange. Conveyance improvements include new piping and ditch conveyance to route storm flows to the new pond, reconstruction of the damaged cross culvert at station 4364, and new catch basins to reconnect treated flows to the wetland.

The major components for collection and conveyance in TDA-F2 are the roadway drainage system for NE 160th Street and a detention pond in the southeast quadrant of the NE 160th Street interchange. Drainage from adjacent residential and commercial areas east converges in the NE 160th Street conveyance system and flows to the detention pond through a system of pipes and catch basins. Water from the detention pond discharges north through a culvert under NE 160th Avenue to an open conveyance ditch running north along the freeway corridor. No storm drainage improvements are proposed for TDA-F2.

TDA-F3 collects freeway runoff in ditches and closed conveyance structures and pipes running down slope north. Flow is routed at intervals through a series of pipes and structures to lateral culverts that discharge along the west side of the freeway to a ravine beginning in the northwest quadrant of the NE 160th Avenue interchange. Five individual cross culverts intersect the freeway within TDA-F3 typically conveying offsite flows combined with on-site freeway runoff.

Off-site flows originate in the adjacent sloping areas lying to the east. Through various portions of the off-site area, runoff sheet flows west through heavily vegetated slopes toward the freeway corridor and/or is collected in a series of open ditches and pipe conveyance systems. Runoff generated in the southern portions of this basin is routed to the east side of the freeway corridor just north of the NE 160th Street interchange. At this point it becomes a roadside ditch running north along the northbound on-ramp for approximately 300 feet before entering a 42 inch cross culvert running northwest under the freeway. The cross drain collects freeway runoff at various intervals through large roadway catch basin structures, and discharges on the west side of the freeway at the head of the aforementioned ravine. Conveyance through the ravine is by a narrow stream with relatively steep sloping sides as it parallels the western edge of the freeway. The first 400 feet of the ravine have been cleared and graded in response to freeway construction and developments to the west.

Proceeding north, the ravine enters a wooded area where it begins to diverge away from the freeway to the northwest. The ravine becomes steeper and deeper as it continues its path down slope to the Sammamish River. The associated drainage is classified a Category 2 stream by the City of Bothell (expected to have continuous flow) with areas down slope existing within designated erosion hazard, landslide hazard and seismic hazard areas. Portions of the ravine are heavily eroded and incised by stream flows, which threaten the stability of associated embankments and the overlying freeway corridor. At the lower end of the ravine the channel flows through residential property before entering a roadside conveyance system along the south side of Riverside Drive. Flowing west for approximately 50 feet, it enters a catch basin structure and associated 18 inch culvert crossing the road north to an open concrete channel flowing north through private property, where it discharges to the Sammamish River.

TDA-F4 encompasses an area of freeway corridor that traverses the surrounding terrain sloping north and west to the Sammamish River. The roadway section is superelevated into the slope. Freeway runoff sheet flows to median shoulder gutters or roadside ditches where it is collected in drainage structures and conveyed down slope to the north. Terrain to the east consists of steep cut slope sections created during freeway construction. Horizontal drains have been installed at intervals along this stretch to collect surface and subterranean flows, thus helping to stabilize the slope. These drains convey water to the roadway ditch and pipe network carrying water down the freeway corridor north then west to outfall in the Sammamish River. A small berm has been constructed paralleling the freeway approximately 60 feet up the embankment to intercept surface flows and reduce erosion of the slope. Drainage inlets are placed at intervals to collect runoff and convey it to the freeway drainage system.

Along the freeways western edge, stormwater from the roadway shoulder sheet flows to a shallow conveyance ditch where it is collected at intervals and conveyed to a closed pipe system paralleling the freeway running north. These flows converge at a catch basin and discharge down slope to the west through a closed conveyance, mingling with the roadway conveyance system for Riverside Drive and discharging to the Sammamish River through a 30 inch concrete outfall pipe.

5.2 PROPOSED CONVEYANCE SYSTEM IMPROVEMENTS

<u>Threshold Discharge Area A1</u> - The existing pavement located on the eastside of the southbound lanes crown, median and northbound lanes will continue to be collected and discharged using the existing drainage system discussed in Section 5.1, with modifications for the widened roadway. The existing pavement collection system is a combination of inlets and storm drains that connect

to open ditches along both sides of the freeway, flowing south to seven individual culvert crossings. The existing cross drain pipes will be adjusted as indicated in Table 2.3 Kirkland Cross Culvert Systems and Expected Impacts.

Threshold Discharge Area A2 - The existing pavement located on the eastside of the southbound lanes crown, median and northbound lanes will continue to be collected and discharged using the existing drainage system discussed in Section 5.1, above. The existing pavement collection system is a combination of inlets and storm drains that connect to open ditches along both sides of the freeway, flowing south to two individual culvert crossings. The existing cross drain pipes will be adjusted as indicated in Table 2.3.

Threshold Discharge Areas B1, B2 and B3: No storm drainage improvements are proposed for these TDAs

Threshold Discharge Area B4: The existing pavement located on the west side of the southbound lanes crown, median and northbound lanes will continue to be collected and discharged using the existing drainage system discussed in Section 5.1, above. The existing pavement collection system is a combination of inlets and storm drains that connect to open ditches along both sides of the freeway, flowing south to be intercepted at the single culvert crossings noted in Section 5.1. The existing cross drain pipe will be adjusted as indicated in Table 2.3.

Threshold Discharge Area C1: The runoff collection system will be largely replaced in the northern portions of this TDA to reflect profile changes in the mainline construction and to provide capacity upgrades. The existing Forbes Creek culvert at station 4180 (MP 19.14) will be replaced to allow fish passage. Section 2.3.3.3 provides a detailed discussion of the proposed fish passage improvements with references to the related calculations and plans. Two existing cross culverts [station 4196 (MP 19.42) and station 4205 (MP 19.59)] will be replaced with a new culverts to route Forbes Creek tributaries under the freeway. Additionally, portions of the existing storm system at NE 116th Street will be replaced to improve drainage capacity and correct flooding issues in the roadway around the interchange area. Table 2.3 lists the proposed adjustments for each of the cross culverts along this stretch of freeway improvements.

Threshold Discharge Area D1: All existing pavement located in TDA-D1 will continue to be collected and discharged using the existing drainage system discussed in Section 5.1, above. A single cross culvert location exists for TDA-D1 at station 4251 (MP 20.46) consisting of twin 42 inch culverts. These culverts will not be impacted by this project. Regrade activity in the interchange area, as part of the proposed flow control pond will include a new ditch to convey freeway runoff to the pond.

Threshold Discharge Area D2: Conveyance facilities in TDA-D2 will remain mostly unchanged. A roadside ditch in the median area will be adjusted with the pavement widening, but will function as before to collect sheet flow from the freeway.

Threshold Discharge Area D3 & D4: Roadside ditches will be adjusted along new pavement widening areas in association with ecology embankment construction. Within the divided median area, flow will continue as before, crossing at one of three existing cross culverts. Along the west side of the freeway, the existing ditch will be adjusted with the roadway widening. Currently, this ditch drains to a Juanita Creek tributary at crossing the freeway at station 4294 (MP 21.27). The proposed system will convey this runoff via closed pipe to the expanded detention pond. Table 2.3 lists the proposed adjustments for each of the cross culverts along this stretch of freeway improvements.

Threshold Discharge Area E1: The integral pipe system of the ecology embankment BMPs constructed along the western edge of the mainline between station 4320 to station 4341 (MP

21.77 to MP 22.17) will be used to convey freeway runoff to the proposed pond facility. All other existing pavement located in TDA-E1 will continue to be collected and discharged using the existing drainage system discussed in Section 5.1, above.

Two cross culvert locations exist for TDA-E1. The main stem of Juanita Creek crosses at station 4328 (MP 21.92). This culvert is maintained by King County as part of their "High Woodlands Detention Facility" and is currently targeted for fish passage upgrades pending decision from WDFW. It is anticipated that King County will be responsible for providing the upgrades as specified in prevailing permit obligations with the State. Section 2.3.3.3 provides a detailed discussion of the proposed fish passage improvements with references to the related calculations and plans. Table 2.3 lists the proposed adjustments for each of the cross culverts along this stretch of freeway improvements.

Threshold Discharge Area E2: Stormwater runoff generated in the center and east side of the freeway will largely continue to be collected and discharged using the existing drainage system discussed in Section 5.1, above. Conveyance improvements will be constructed along the west side to accommodate the new pavement widening and associated on-ramp improvements. Existing cross drains will be extended to span the widened portion of freeway. Table 2.3 lists the proposed adjustments for each of the cross culverts along this stretch of freeway improvements. Additionally, a new conveyance pipe will extend along portions of the west side to collect freeway drainage from the existing cross drains and from the proposed ecology embankments. The conveyance pipe will be integrated with proposed roadway, retaining walls and ecology embankment facilities, and will discharge to the proposed pond located near the existing natural drainage course. In the unpaved area between the southbound mainline and the southbound on-ramp, a new ditch will be constructed to collect and convey runoff to the existing cross drains and flow control facility.

Threshold Discharge Area E3: TDA-E3 encompasses the Brickyard Park and Ride facility and associated areas. No roadway or storm drainage improvements are proposed for the Kirkland Nickel project in this basin.

Threshold Discharge Area F1: Existing storm drainage infrastructure discussed in Section 5.1, will remain unchanged to the maximum extent practicable, with few improvements. Conveyance improvements for TDA-F1 include a single existing cross culvert at station 4364 (MP 22.59) to be replaced due to damage received during previous construction of bridge improvements. The crossing location will be altered slightly to shorten the boring distance and to avoid bridge piles in the center median. Additional catch basin structures and piping will be used to connect with existing storm drain infrastructure and route flows to the basin outfall. Table 2.3 lists the proposed adjustments for this new culvert.

Threshold Discharge Area F2: TDA-F2 encompasses eastern portions of the NE 160th Street interchange and associated areas. No roadway or storm drainage improvements are proposed for the Kirkland Nickel project in this basin.

Threshold Discharge Area F3 & F4: To convey freeway runoff to the combined stormwater facility in the lower ravine, a pipe system will be constructed along the west side of the freeway mainline to collect and convey on-site freeway runoff. This configuration will change the existing drainage patterns slightly by routing freeway runoff around the ravine area, thus helping to reduce scour in the streambed and decreasing the source of surface water erosion on the associated roadway embankment. Along the east side of the freeway another bypass line will be constructed to collect off-site runoff from uphill areas to the east and convey it north along the freeway to a flow splitter. The flow splitter will distribute the runoff through existing drainage infrastructure to discharge at three separate existing outfalls to the Sammamish River. See Appendix B for proposed drainage plans.

To separate on-site from off-site runoff, new catch basin inlet structures will be installed along the eastern edge of the mainline. Inlets will be situated to connect with the existing storm drain piping under the freeway. New curbing will be constructed along the east edge to intercept and channel freeway runoff to the new drain inlets. The cross drain piping will terminate at the new inlet structures so as to prohibit the mingling of off-site runoff. The new off-site bypass system will be constructed along the eastern edge of the freeway with a closed pipe system and improved conveyance ditches to replace the existing storm drainage facilities. Both bypass lines will be constructed to function with Nickel phase and future Implementation phase freeway configurations. The design-build contractor will be responsible for the design of all bypass conveyance systems, including flow splitter structures, stilling wells, piping over steep slopes, and all associated features of the proposed system.

At the City of Bothell's request, additional conveyance analyses were performed for the drainage ravine and associated outlet to the Sammamish River, particularly regarding capacity of the existing culvert under Riverside Drive. Analyses were performed to satisfy the requirements of King County Level 3 downstream analysis related to the proposed Pond/Wetland F3 as shown in the Phase 2 Kirkland Nickel Project plans and as provided in this report.

King County Core Requirement #2: Offsite Analysis notes that the intent of the downstream analysis is "to identify existing or potential/predicable downstream flooding and erosion problems so that the appropriate mitigation, as Specified in Section 1.2.2.2 (p. 1-24), can be provided to prevent aggravation of these problems."

Based on the calculations, it was confirmed that the existing Riverside Drive culvert is undersized for the anticipated 100-year recurrent design storm peak flows. The proposed design is expected to partly mitigate this deficiency by decreasing peak flows by approximately 20 percent. The duration analysis also shows that the project condition decreases the durations that any given flow rate occurs in the downstream systems. Calculations and findings are included with this report as Appendix F.

6 UTILITY IMPACTS

Proposed roadway and stormwater improvement work will impact existing utilities, including water, sanitary sewer, telephone and buried cable, electric lines and poles/towers, and gas lines. Proposed stormwater designs will attempt to reduce the number of utility conflicts, yet relocation will be required in some instances where proposed construction impacts are unavoidable. The I-405 Team is working with local utility purveyors to coordinate potential utility adjustments. The following utility conflicts are known to existing for the Stage 1 construction effort:

City of Kirkland 18 inch PVC Sanitary Sewer Line (crossing I-405)

The I-405 mainline will be widened in the vicinity of NE 116th Street and an existing 18 inch sanitary sewer line. The sewer line rests within a 30 inch steel casing. The proposed NB edge of pavement will be located approximately 70 feet further to the east of the existing pavement edge. A retaining wall (fill) will be constructed along the eastern edge of pavement to keep the roadway grading within the existing right-of-way. The proposed SB edge of pavement will be approximately 40 feet further to the west of the existing pavement edge. A retaining wall (fill) will be constructed along the western edge of pavement to keep the roadway grading within the existing right-of-way. The 30 inch steel casing will be extended to enclose and protect the sewer line under the proposed pavement. Retaining wall construction will be coordinated with the existing sewer alignment.

Private Storm Sewer at NB to NE 116th St. Off-Ramp (crossing ramp)

A private commercial development at the corner of NE 116th Street and the NB off-ramp discharges stormwater from an existing detention system to a structure in the WSDOT right-of-way along the NB off-ramp; which will be reconstructed. The eastern edge of pavement at the storm sewer will be widened by approximately 12 feet. The existing junction structure along the existing ramp appears to have no conflict, but will require adjustment to grade. The location appears to be within the proposed pork chop island. Additional piping and structures may be necessary to reconnect this system to the new storm system in NE 116th Street.

The I-405 team has expended considerable effort to identify and avoid utility conflicts along the alignment. However, it is assumed that unforeseen conflicts will arise during the course of construction. The design-builder will take ownership of the design upon Notice-To-Proceed, and has the authority to make design revisions and changes.

7 RIGHT-OF-WAY IMPACTS

New right-of-way will be required for the addition of three proposed BMP facilities. Additionally, permanent drainage easements will be established through selected private properties to convey runoff to or from the proposed stormwater facilities. Table 6.1 lists the associated parcels targeted for impacts in relation to stormwater treatment.

Table 7.1 Right of Way Acquisition Areas

Project Parcel #	Tax Account #	Acquisition Area (sf)	Reason for Acquisition	Easement Area (sf)	Easement Type
Stage 1					
354	3326059064			1,105	Subterranean
	Unknown		Wetland Mitigation		
	12385007050900	69,696	Wetland Mitigation		
	27053000100600	413,820	Wetland Mitigation		
	27053000102200	202,118	Wetland Mitigation		
	27053000401400	133,294	Wetland Mitigation		
Stage 1 Total		818,928		1,105	
Stage 2					
1036	1726059041	65,340	Detention Pond		
540	1726059044	61,162	Detention Pond Roadway Slopes		
	0961100032			2,320	TCE / Permanent Drainage
	0961100033	40,042	Detention Pond		
	0961100030			6,175	TCE / Permanent

Project Parcel #	Tax Account #	Acquisition Area (sf)	Reason for Acquisition	Easement Area (sf)	Easement Type
					Drainage
	0961100048				Permanent Drainage
	0961100050				Permanent Drainage
Stage 2 Total		166,544		8,495	
Totals		985,472		9,600	

* Existing parcel size taken from KC Metro Parcel Viewer. Parcel areas measured on screen may differ.

8 APPENDICES

APPENDIX A; CALCULATIONS AND DRAINAGE MAPS (BASINS, SUBBASINS, AREA AND LABELS, CROSS DRAINS AND MAJOR FLOW PATHES)

APPENDIX B; DRAINAGE PLANS (PRELIMINARY CONVEYANCE, TREATMENT FACILITIES, SUB-BASINS, EXISTING CONDITIONS, TYPICAL SECTIONS, DETAILS)

APPENDIX C; STORMWATER DESIGN CRITERIA TECHNICAL MEMORANDA

APPENDIX D; STORMWATER DESIGN DECISION REPORTS

APPENDIX E; FISH PASSAGE IMPROVEMENTS

APPENDIX F; DOWNSTREAM ANALYSIS – PROJECT INFLUENCE ON THE RIVERSIDE DRIVE CULVERT AND ASSOCIATED OUTFALL IN BOTHELL

APPENDIX A

CALCULATIONS AND DRAINAGE MAPS (BASINS, SUBBASINS, AREA ACRES AND LABELS, CROSS DRAINS AND MAJOR FLOW PATHES)

BASIN AREA SUMMARIES

AREA SUMMARY BY WATERSHED

NICKEL STAGE 1 & 2

Watershed	Existing Impervious	New Impervious	Replaced Impervious	Removed Impervious	50% RULE NEW	50% RULE NEW & REPLACED
Lake Washington East Bellevue North	2,299,615	66,952	244,696	0	2.9%	13.6%
Forbes Creek	1,774,956	434,214	482,417	73,627	24.5%	51.6%
Juanita Creek	3,598,490	156,643	209,162	35,015	4.4%	10.2%
Sammamish River	1,372,109	44,507	50,989	1,464	3.2%	7.0%
Total Kirkland Segment	**9,045,170**	**702,316**	**987,264**	**110,106**	**7.8%**	**18.7%**

	Existing Impervious Area			
Lake Washington East Bellevue North	Forbes Creek	Juanita Creek	Sammamish River	Kirkland Segment Total
134,798	169,448	1,844,786	276,376	
171,352	135,036	471,748	229,321	
313,041	98,010	235,281	584,442	
807,837	233,482	227,285	281,970	
356,979	504,151	292,924		
		301,499		
515,608	237,684	224,967		
	191,203			
	-6,770			
	-10,131			
	222,843			
2,299,615	1,774,956	3,598,490	1,372,109	9,045,170

	New Impervious Area			
Lake Washington East Bellevue North	Forbes Creek	Juanita Creek	Sammamish River	Kirkland Segment Total
47,147	418,783	32,742	9,881	
19,270	15,431	2,102	0	
535		23,009	34,626	
0		20,558	0	
0		35,940		
		42,292		
		0		
66,952	434,214	156,643	44,507	702,316

	Replaced Impervious Area			
Lake Washington East Bellevue North	Forbes Creek	Juanita Creek	Sammamish River	Kirkland Segment Total
32,090	7,436	77,848	10,892	
12,268	4,817	2,589	0	
46,409	11,259	17,364	38,643	
73,718	6,513	27,038	1,454	
42,790	13,795	27,703		
6,611	40,560	56,620		
8,664	122,921			
	24,671			
	68,367			
	28,871			
9,937	15,635			
12,209	952			
	19,489			
	16,428			
	21,510			
	4,121			
	22,386			
	11,838			
	6,806			
	19,717			
	6,019			
	3,711			
	4,595			
244,696	482,417	209,162	50,989	987,264

	Removed Impervious Area			
Lake Washington East Bellevue North	Forbes Creek	Juanita Creek	Sammamish River	Kirkland Segment Total
	73,627	7,815	1,464	
	0	27,200		
0	73,627	35,015	1,464	110,106

TDA included

Lake Washington East Bellevue North	A, B, part B-4
Forbes Creek	part B-4, C
Juanita Creek	D, E
Sammamish River	F

BASIN AREA SUMMARY

	STAGE 1						STAGE 2						NICKEL TOTAL					
	NEW IMPERVIOUS		REPLACED IMPERVIOUS		REMOVED IMPERVIOUS		NEW IMPERVIOUS		REPLACED IMPERVIOUS		REMOVED IMPERVIOUS		NEW IMPERVIOUS		REPLACED IMPERVIOUS		REMOVED IMPERVIOUS	
BASIN	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC	SF	AC
A-1	0	0.00	0	0.00	0	0.00	47,147	1.08	32,090	0.74	0	0.00	47,147	1.08	32,090	0.74	0	0.00
A-2	0	0.00	0	0.00	0	0.00	19,270	0.44	12,268	0.28	0	0.00	19,270	0.44	12,268	0.28	0	0.00
B-1	0	0.00	0	0.00	0	0.00	535	0.01	46,409	1.07	0	0.00	535	0.01	46,409	1.07	0	0.00
B-2	0	0.00	0	0.00	0	0.00	0	0.00	73,718	1.69	0	0.00	0	0.00	73,718	1.69	0	0.00
B-3	0	0.00	0	0.00	0	0.00	0	0.00	42,790	0.98	0	0.00	0	0.00	42,790	0.98	0	0.00
B-4	15,431	0.35	75,072	1.72	0	0.00	0	0.00	37,421	0.86	0	0.00	15,431	0.35	112,493	2.58	0	0.00
C	263,826	6.06	338,978	7.78	73,627	1.69	154,957	3.56	68,367	1.57	0	0.00	418,783	9.61	407,345	9.35	73,627	1.69
D-1	7,347	0.17	69,999	1.61	7,815	0.18	25,395	0.58	7,849	0.18	0	0.00	32,742	0.75	77,848	1.79	7,815	0.18
D-2	0	0.00	0	0.00	0	0.00	2,102	0.05	2,589	0.06	0	0.00	2,102	0.05	2,589	0.06	0	0.00
D-3	0	0.00	0	0.00	0	0.00	23,009	0.53	17,364	0.40	0	0.00	23,009	0.53	17,364	0.40	0	0.00
D-4	0	0.00	0	0.00	0	0.00	20,558	0.47	27,038	0.62	0	0.00	20,558	0.47	27,038	0.62	0	0.00
E-1	0	0.00	0	0.00	0	0.00	35,940	0.83	27,703	0.64	0	0.00	35,940	0.83	27,703	0.64	0	0.00
E-2	0	0.00	0	0.00	0	0.00	42,292	0.97	56,620	1.30	28,134	0.65	42,292	0.97	56,620	1.30	28,134	0.65
E-3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
F-1	0	0.00	0	0.00	0	0.00	9,881	0.23	10,892	0.25	1,464	0.03	9,881	0.23	10,892	0.25	1,464	0.03
F-2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
F-3	0	0.00	0	0.00	0	0.00	34,626	0.79	38,643	0.89	0	0.00	34,626	0.79	38,643	0.89	0	0.00
F-4	0	0.00	0	0.00	0	0.00	0	0.00	1,454	0.03	0	0.00	0	0.00	1,454	0.03	0	0.00
TOTAL	**286,604**	**6.58**	**484,049**	**11.11**	**81,442**	**1.87**	**415,712**	**9.54**	**503,215**	**11.55**	**29,598**	**0.68**	**702,316**	**16.12**	**987,264**	**22.66**	**111,040**	**2.55**
TOTAL STG 1 & 2	**702,316**	**16.12**	**987,264**	**22.66**	**111,040**	**2.55**												

BASIN A AND B CATCHMENT AREAS

Catchment Name	A.1					
	Stage 1		Stage 2		Total Nickel	
Pre-Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
Basin	350,381	8.04	350,381	8.04	350,381	8.04
Existing Impervious	134,798	3.09	134,798	3.09	134,798	3.09
Post Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
New Pavement	0	0.00	47,147	1.08	47,147	1.08
Replaced Pavement	0	0.00	32,090	0.74	32,090	0.74
Removed Pavement	0	0.00		0.00	0	0.00
Pond Surface	0	0.00	0	0.00	0	0.00
Total Impervious	***0***	***0.00***	***79,237***	**1.82**	***79,237***	**1.82**
Pervious area	350,381	8.04	271,144	6.22	271,144	6.22
75% Forest	***262,786***	***6.03***	***203,358***	***4.67***	***203,358***	***4.67***
25% Pasture	***87,595***	***2.01***	***67,786***	***1.56***	***67,786***	***1.56***
Catchment Name	**B-4 Forbes Basin**					
	Stage 1		**Stage 2**		**Total Nickel**	
Pre-Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
Basin	1,187,075	27.25	1,187,075	27.25	1,187,075	27.25
Existing Impervious	634,830	14.57	634,830	14.57	634,830	14.57
Post Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
New Pavement	15,431	0.35	0	0.00	15,431	0.35
Replaced Pavement	75,072	1.72	37,421	0.86	112,493	2.58
Removed Pavement	0	0.00		0.00	0	0.00
Pond Surface	0	0.00	0	0.00	0	0.00
Total Impervious	***90,503***	***2.08***	***37,421***	**0.86**	***127,924***	**2.94**
Pervious area	1,096,572	25.17	1,149,654	26.39	1,059,151	24.31
75% Forest	***822,429***	***18.88***	***862,241***	***19.79***	***794,363***	***18.24***
25% Pasture	***274,143***	***6.29***	***287,414***	***6.60***	***264,788***	***6.08***

BASIN C CATCHMENT AREAS

Catchment Name	C.1					
	Stage 1		Stage 2		Total Nickel	
Pre-Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
Basin	345,462	7.93	345,462	7.93	345,462	7.93
Existing Impervious	169,448	3.89	169,448	3.89	169,448	3.89
Post Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
New Pavement	37,580	0.86	0	0.00	37,580	0.86
Replaced Pavement	25,631	0.59		0.00	25,631	0.59
Removed Pavement	0	0.00		0.00	0	0.00
Pond Surface	0	0.00	0	0.00	0	0.00
Total Impervious	***63,211***	***1.45***	***0***	**0.00**	***63,211***	**1.45**
Pervious area	282,251	6.48	345,462	7.93	282,251	6.48
75% Forest	***211,688***	***4.86***	***259,097***	***5.95***	***211,688***	***4.86***
25% Pasture	***70,563***	***1.62***	***86,366***	***1.98***	***70,563***	***1.62***

Catchment Name	C.2					
	Stage 1		Stage 2		Total Nickel	
Pre-Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
Basin	394,266	9.05	394,266	9.05	394,266	9.05
Existing Impervious	135,036	3.10	135,036	3.10	135,036	3.10
Post Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
New Pavement	34,922	0.80	0	0.00	34,922	0.80
Replaced Pavement	16,428	0.38		0.00	16,428	0.38
Removed Pavement	0	0.00		0.00	0	0.00
Pond Surface	0	0.00	0	0.00	0	0.00
Total Impervious	***51,350***	***1.18***	***0***	**0.00**	***51,350***	**1.18**
Pervious area	342,916	7.87	394,266	9.05	342,916	7.87
75% Forest	***257,187***	***5.90***	***295,700***	***6.79***	***257,187***	***5.90***
25% Pasture	***85,729***	***1.97***	***98,567***	***2.26***	***85,729***	***1.97***

Catchment Name	C.1 + C.2					
	Stage 1		Stage 2		Total Nickel	
Pre-Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
Basin	739,728	16.98	739,728	16.98	739,728	16.98
Existing Impervious	304,484	6.99	304,484	6.99	304,484	6.99
Post Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
New Pavement	72,502	1.66	0	0.00	72,502	1.66
Replaced Pavement	42,059	0.97	0	0.00	42,059	0.97
Removed Pavement	0	0.00		0.00	0	0.00
Pond Surface	0	0.00	0	0.00	0	0.00
Total Impervious	***114,561***	***2.63***	***0***	***0.00***	***114,561***	***2.63***
Pervious area	625,167	14.35	739,728	16.98	625,167	14.35
75% Forest	***468,875***	***10.76***	***554,796***	***12.74***	***468,875***	***10.76***
25% Pasture	***156,292***	***3.59***	***184,932***	***4.25***	***156,292***	***3.59***

Catchment Name	C.4					
	Stage 1		Stage 2		Total Nickel	
Pre-Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
Basin	534,322	12.27	534,322	12.27	534,322	12.27
Existing Impervious	233,482	5.36	233,482	5.36	233,482	5.36
Post Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
New Pavement	16,808	0.39	40,640	0.93	57,448	1.32
Replaced Pavement	28,871	0.66		0.00	28,871	0.66
Removed Pavement		0.00		0.00	0	0.00
Pond Surface	0	0.00	0	0.00	7,317	0.17
Total Impervious	***45,679***	***1.05***	***40,640***	***0.93***	***86,319***	***1.98***
Pervious area	488,643	11.22	#REF!	#REF!	448,003	10.28
75% Forest	***366,482***	***8.41***	***#REF!***	***#REF!***	***336,002***	***7.71***
25% Pasture	***122,161***	***2.80***	***#REF!***	***#REF!***	***112,001***	***2.57***

Catchment Name	C.5					
	Stage 1		Stage 2		Total Nickel	
Pre-Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
Basin	952,443	21.87	952,443	21.87	952,443	21.87
Existing Impervious	504,151	11.57	504,151	11.57	504,151	11.57
Post Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
New Pavement	63,766	1.46	114,317	2.62	178,083	4.09
Replaced Pavement	231,972	5.33	68,367	1.57	300,339	6.89
Removed Pavement	73,627	1.69		0.00	73,627	1.69
Pond Surface	0	0.00	0	0.00	0	0.00
Total Impervious	***222,111***	***5.10***	***182,684***	***4.19***	***404,795***	***9.29***
Pervious area	730,332	16.77	769,759	17.67	547,648	12.57
75% Forest	***547,749***	***12.57***	***577,319***	***13.25***	***410,736***	***9.43***
25% Pasture	***182,583***	***4.19***	***192,440***	***4.42***	***136,912***	***3.14***

Catchment Name	C.3					
	Stage 1		Stage 2		Total Nickel	
Pre-Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
Basin	432,593	9.93	432,593	9.93	432,593	9.93
Existing Impervious	98,010	2.25	98,010	2.25	98,010	2.25
Post Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
New Pavement	110,750	2.54	0	0.00	110,750	2.54
Replaced Pavement	36,067	0.83		0.00	36,067	0.83
Removed Pavement	0	0.00		0.00	0	0.00
Pond Surface	0	0.00	0	0.00	0	0.00
Total Impervious	***146,817***	3.37	***0***	0.00	***146,817***	3.37
Pervious area	285,776	6.56	432,593	9.93	285,776	6.56
75% Forest	***214,332***	***4.92***	***324,445***	***7.45***	***214,332***	***4.92***
25% Pasture	***71,444***	***1.64***	***108,148***	***2.48***	***71,444***	***1.64***

Catchment Name	C.3 + C.4 + C.5					
	Stage 1		Stage 2		Total Nickel	
Pre-Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
Basin	1,919,358	44.06	1,919,358	44.06	1,919,358	44.06
Existing Impervious	835,643	19.18	835,643	19.18	835,643	19.18
Post Developed	Area (sf)	Area (acres)	Area (sf)	Area (acres)	Area (sf)	Area (acres)
New Pavement	191,324	4.39	154,957	3.56	346,281	7.95
Replaced Pavement	296,910	6.82	68,367	1.57	365,277	8.39
Removed Pavement	73,627	1.69	0	0.00	73,627	1.69
Pond Surface	0	0.00	0	0.00	0	0.00
Total Impervious	***414,607***	***9.52***	***223,324***	*5.13*	***637,931***	***14.64***
Pervious area	1,504,751	34.54	1,696,034	38.94	1,281,427	29.42
75% Forest	***1,128,563***	***25.91***	***1,272,026***	***29.20***	***961,070***	***22.06***
25% Pasture	***376,188***	***8.64***	***424,009***	***9.73***	***320,357***	***7.35***

Total New	263,826	6.06	154,957	3.56	418,783	9.61

Basin A **NICKEL ST 1 & 2**

A-1	**Area (sf)**	**Area (ac)**			
EXISTING					
Basin Area	4,954,974	113.75			
Impervious	2,541,166	58.34			
Pervious	2,413,808	55.41			
PROPOSED					
New Pavement	47,147	1.08			
Remove & Replace	32,090	0.74			
Remove w/o Replace	0	0.00			
Pervious	2,366,661	54.33			
area check	*4,954,974*	*114.00*	*4954974.0*	*OK*	
change in Perv.	*47,147*	*1.08*			
Min. Req. 1-4 check	*79,237*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*47,147*	***REQUIRED***			
net new impervious	*47,147*	***REQUIRED***			
50% of Existing Imp.	*1,270,583*	***EXEMPT***			

A-2	**Area (sf)**	**Area (ac)**			
EXISTING					
Basin Area	295,321	6.78			
Impervious	171,352	3.93			
Pervious	123,969	2.85			
PROPOSED					
New Pavement	19,270	0.44			
Remove & Replace	12,268	0.28			
Remove w/o Replace	0	0.00			
Pervious	104,699	2.40			
area check	*295,321*	*6.78*	*6.8*	*OK*	
change in Perv.	*19,270*	*0.44*			
Min. Req. 1-4 check	*31,538*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*19,270*	***REQUIRED***			
net new impervious	*19,270*	***REQUIRED***			
50% of Existing Imp.	*85,676*	***EXEMPT***			

Calculation of Areas in Drainage Basin A

	A1		A2					
	sf	acre	sf	acre	sf	acre	sf	acre
Basin	4,954,974	113.8	295,321	6.8		0		0
Existing Impervious	2,541,166	58.3	171,352	3.9	0	0	0	0
Remove & Replace	32,090	0.7	12,268	0.3				
Remove w/o Replace	0	0.0	0	0.0				
New Pavement	47,147	1.1	19,270	0.4				

Existing	A1			A2								
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		3066123			171352							
		-6,081										
		-11,673										
		-22,859										
		-20,591										
		-26,476										
		-8,060										
		-9,210										
		-5579										
		-15093										
		-27325										
		-60218										
		-51257										
		-90345										
		-103814										
		-6451										
		-2997										
		-5064										
		-33903										
		-17961										
Total		2,541,166			171,352			0			0	

Remove & Replace	A1			A2								
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		32090			9478							
					2,790							
Total		32,090			12,268			0			0	

New Pavement	A1			A2								
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		47147			19270							
					0							
Total		47,147			19,270			0			0	

Remove w/o Replace	A1			A2								
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
Total		0			0			0			0	

Basin B **Nickel ST 1 & 2**

B-1	Area (sf)	Area (ac)			
EXISTING					
Basin Area	834,271	19.15			
Impervious	313,041	7.19			
Pervious	521,230	11.97			
		0.00			
PROPOSED		0.00			
New Pavement	535	0.01			
Remove & Replace	46,409	1.07			
Remove w/o Replace	0	0.00			
Pervious	520,695	11.95			
		0.00			
area check	*834,271*	19.15	*19*	*OK*	
change in Perv.	*535*	0.01			
Min. Req. 1-4 check	*46,944*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*535*	***EXEMPT***			
net new impervious	*535*	***EXEMPT***			
50% of Existing Imp.	*156,521*	***EXEMPT***			

B-2	Area (sf)	Area (ac)			
EXISTING					
Basin Area	1,522,455	34.95			
Impervious	807,837	18.55			
Pervious	714,618	16.41			
		0.00			
PROPOSED		0.00			
New Pavement	0	0.00			
Remove & Replace	73,718	1.69			
Remove w/o Replace	0	0.00			
Pervious	714,618	16.41			
		0.00			
area check	*1,522,455*	34.95	*35*	*OK*	
change in Perv.	*0*	0.00			
Min. Req. 1-4 check	*73,718*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*0*	***EXEMPT***			
net new impervious	*0*	***EXEMPT***			
50% of Existing Imp.	*403,919*	***EXEMPT***			

B-3	Area (sf)	Area (ac)			
EXISTING					
Basin Area	797,537	18.31			
Impervious	356,979	8.20			
Pervious	440,558	10.11			
		0.00			
PROPOSED		0.00			
New Pavement	0	0.00			
Remove & Replace	42,790	0.98			
Remove w/o Replace	0	0.00			
Pervious	440,558	10.11			
		0.00			
area check	*797,537*	18.31	*18*	*OK*	
change in Perv.	*0*	0.00			
Min. Req. 1-4 check	*42,790*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*0*	***EXEMPT***			
net new impervious	*0*	***EXEMPT***			
50% of Existing Imp.	*178,490*	***EXEMPT***			

B-4 Stg 1	Area (sf)	Area (ac)			
EXISTING					
Basin Area	2,183,393	50.12			
Impervious	1,150,437	26.41			
Pervious	1,032,956	23.71			
		0.00			
PROPOSED		0.00			
New Pavement	15,431	0.35			
Remove & Replace	75,072	1.72			
Remove w/o Replace	0	0.00			
Pervious	1,017,525	23.36			
		0.00			
area check	*2,183,393*	50.12	*2183393*	*OK*	
change in Perv.	*15,431*	0.35			
Min. Req. 1-4 check	*90,503*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*15,431*	***REQUIRED***			
net new impervious	*90,503*	***REQUIRED***			
50% of Existing Imp.	*575,219*	***EXEMPT***			

B4 Stage 2	Area (sf)	Area (ac)			
PROPOSED					
New Pavement (PGIS)	*0*	0.00			
Remove & Replace	37,421	0.86			
Remove w/o Replace	0	0.00			
Total	**Area (sf)**	**Area (ac)**			
PROPOSED					
New Pavement (PGIS)	*15,431*	0.35			
Remove & Replace	112,493	2.58			
Remove w/o Replace	0	0.00			
Net new surface	15,431	0.35			
Pervious	1,017,525	23.36			
Min. Req. 1-4 check	*127,924*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*15,431*	***REQUIRED***			
net new impervious	*127,924*	***REQUIRED***			
50% of Existing Imp.	*1,091,697*	***EXEMPT***			

Calculation of Areas in Drainage Basin B

	B1		B2		B3		B4 Stg 1		B4 Stg 2	
	sf	acre	sf	acre	sf	acre	sf	acre	sf	acre
Basin	834,271	19.2	1,522,455	35.0	797,537	18.3	2,183,393	50.1	2,183,393	50.1
Existing Impervious	313,041	7.2	807,837	18.5	356,979	8.2	1,150,437	26.4	0	0.0
Remove & Replace	46,409	1.1	73,718	1.7	42,790	1.0	75,072	1.7	37,421	0.9
Remove w/o Replace	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
New Pavement	535	0.0	0	0.0	0	0.0	15,431	0.4	0	0.0

Existing	B1			B2			B3			B4 Stg 1		
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		250664			89309			13251			222,843	
		62,377			346,380			71,560			591,441	
					378,077			218,071			191,203	
					-1,929			45,588			-6,770	
					-4,000			8,509			-10,131	
											161,851	
Total		313,041			807,837			356,979			1,150,437	

Remove & Replace	B1			B2			B3			B4 Stg 1			B4 Stg 2		
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		3158			11596			13523			4,595			6,611	
		1,320			16,561			17,379			6,019			8,664	
		8,010			17,868			11,888			3,711				
		13,654			27,693						22,386				
		5,845									11,838				
		14,422									6,806				
											19,717			9,937	
														12,209	
Total		46,409			73,718			42,790			75,072			37,421	

New Pavement	B1			B2			B3			B4 Stg 1			B4 Stg 2		
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		535									11,401			0	
											1,660				
											2370				
Total		535			0			0			15,431			0	

Remove w/o Replace	B1			B2			B3			B4 Stg 1			B4 Stg 2		
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
Total		0			0			0			0			0	

Basin C **NICKEL ST 1 & 2**

Stage 1	**Area (sf)**	**Area (ac)**			
EXISTING					
Basin Area	2,658,972	61.04			
Impervious	1,140,127	26.17			
Pervious	1,518,845	34.87			
PROPOSED					
New Pavement (PGIS)	*263,826*	6.06			
Remove & Replace	338,978	7.78			
Remove w/o Replace	73,627	1.69			
Pervious	2,395,146	54.98			
Prairie (25%)	598,787	13.75			
Forest (75%)	1,796,360	41.24			
area check	*2,658,972*	61.04	*2,658,972*	*OK*	
change in Perv.	*-876,301*	-20.12			
Min. Req. 1-4 check	*602,804*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*263,826*	***REQUIRED***			
net new impervious	*190,199*	***REQUIRED***			
50% of Existing Imp.	*570,064*	***EXEMPT***			

Stage 2	**Area (sf)**	**Area (ac)**			
PROPOSED					
New Pavement (PGIS)	*154,957*	3.56			
Remove & Replace	68,367	1.57			
Remove w/o Replace	0	0.00			
Total	**Area (sf)**	**Area (ac)**			
PROPOSED					
New Pavement (PGIS)	*418,783*	9.61			
Remove & Replace	407,345	9.35			
Remove w/o Replace	73,627	1.69			
Pervious	2,240,189	51.43			
Prairie (25%)	560,047	12.86			
Forest (75%)	1,680,142	38.57			
area check	*2,658,972*	61.04	*2,658,972*	*OK*	
change in Perv.					
Min. Req. 1-4 check	*826,128*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*418,783*	***REQUIRED***			
net new impervious	*345,156*	***REQUIRED***			
50% of Existing Imp.	*570,064*	***EXEMPT***			

Calculation of Areas in Drainage Basin C

	st 1		st 2					
	sf	acre	sf	acre	sf	acre	sf	acre
Basin	2,658,972	61.04		0.00				
Existing Impervious	1,140,127	26.17	0	0.00				
Remove & Replace	338,978	7.78	68,367	1.57				
Remove w/o Replace	73,627	1.69	0	0.00				
New Pavement	263,826	6.06	154,957	3.56				

Existing	stage 1			stage 2								
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		373395										
		744,176										
		22,556										
Total		1,140,127			0			0			0	

Remove & Replace	C											
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
	C.5	7436										
		4,817		C.5	68367							
		11259										
		6,513										
		13,795										
		40,560										
		122,921										
		24,671										
	C.4	28,871										
	C.3	15,635										
		952										
		19,489										
	C.2	16428										
	C.1	21510										
		4121										
Total		338,978			68,367			0			0	

New Pavement	C											
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
	C.1	6900										
		30680		C.4	40640							
	C.2	34922		C.5	80558							
	C.3	12126			1729							
		98624			1194							
	C.4	16808			5115							
	C.5	5101			4938							
		26,546			8805							
		9,820			5794							
		11,125			5071							
		11,174			422							
					403							
					288							
Total		263,826			154,957			0			0	

Remove w/o Replace	C											
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
	C.5	2866			0							
		4,705										
		55,292										
		10,764										
Total		73,627			0			0			0	

Basin D **NICKEL ST 1 & 2**

D-1 Stage 1	Area (sf)	Area (ac)			
EXISTING					
Basin Area	3,219,169	73.90			
Impervious	1,844,786	42.35			
Pervious	1,374,383	31.55			
PROPOSED					
New Pavement (PGIS)	7,347	0.17			
Remove & Replace	69,999	1.61			
Remove w/o Replace	7,815	0.18			
Net new surface	-468	-0.01			
Pervious	3,219,637	73.91			
area check	*3,219,169*	73.90	*3,219,169*	*OK*	
change in Perv.	*-1,845,254*	-42.36			
Min. Req. 1-4 check	*77,346*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*7,347*	***REQUIRED***			
net new impervious	*69,531*	***REQUIRED***			
50% of Existing Imp.	*922,393*	***EXEMPT***			

D1 Stage 2	Area (sf)	Area (ac)			
PROPOSED					
New Pavement (PGIS)	*25,395*	0.58			
Remove & Replace	7,849	0.18			
Remove w/o Replace	0	0.00			
Total	**Area (sf)**	**Area (ac)**			
PROPOSED					
New Pavement (PGIS)	*32,742*	0.75			
Remove & Replace	77,848	1.79			
Remove w/o Replace	7,815	0.18			
Net new surface	24,927	0.57			
Pervious	3,194,242	73.33			
Min. Req. 1-4 check	*110,590*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*32,742*	***REQUIRED***			
net new impervious	*102,775*	***REQUIRED***			
50% of Existing Imp.	*#REF!*	***#REF!***			

D-2	Area (sf)	Area (ac)			
EXISTING					
Basin Area	1,019,963	23.42			
Impervious	471,748	10.83			
Pervious	548,215	12.59			
PROPOSED					
New Pavement (PGIS)	*2,102*	0.05			
Remove & Replace	2,589	0.06			
Remove w/o Replace	0	0.00			
Pervious	1,017,861	23.37			
area check	*1,019,963*	23.42	*1,019,963*	*OK*	
change in Perv.	*-469,646*	-10.78			
Min. Req. 1-4 check	*4,691*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*2,102*	***EXEMPT***			
net new impervious	*4,691*	***EXEMPT***			
50% of Existing Imp.	*235,874*	***EXEMPT***			

D-3	Area (sf)	Area (ac)			
EXISTING					
Basin Area	851,903	19.56			
Impervious	235,281	5.40			
Pervious	616,622	14.16			
PROPOSED					
New Pavement (PGIS)	*23,009*	0.53			
Remove & Replace	17,364	0.40			
Remove w/o Replace	0	0.00			
Pervious	828,894	19.03			
area check	*851,903*	19.56	*851,903*	*OK*	
change in Perv.	*-212,272*	-4.87			
Min. Req. 1-4 check	*40,373*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*23,009*	***REQUIRED***			
net new impervious	*40,373*	***REQUIRED***			
50% of Existing Imp.	*117,641*	***EXEMPT***			

D-4	Area (sf)	Area (ac)			
EXISTING					
Basin Area	665,955	15.29			
Impervious	227,285	5.22			
Pervious	438,670	10.07			
PROPOSED					
New Pavement (PGIS)	*20,558*	0.47			
Remove & Replace	27,038	0.62			
Remove w/o Replace	0	0.00			
Pervious	645,397	14.82			
area check	*665,955*	15.29	*665,955*	*OK*	
change in Perv.	*-206,727*	-4.75			
Min. Req. 1-4 check	*47,596*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*20,558*	***REQUIRED***			
net new impervious	*47,596*	***REQUIRED***			
50% of Existing Imp.	*113,643*	***EXEMPT***			

Calculation of Areas in Drainage Basin D

***uses areas found on S:\000\drainage\kirkland\drawings\kirkland drainage 2J.dgn*

	D1 Stg 1		D2		D3		D4		D1 Stg 2	
	sf	acre	sf	acre	sf	acre	sf	acre	sf	acre
Basin	3,219,169	73.90	1,019,963	23.42	851,903	19.56	665,955	15.29	3,219,169	73.90
Existing Impervious	1,844,786	42.35	471,748	10.83	235,281	5.40	227,285	5.22	1,844,786	42.35
Remove & Replace	69,999	1.61	2,589	0.06	17,364	0.40	27,038	0.62	7,849	0.18
Remove w/o Replace	7,815	0.18	0	0.00	0	0.00	0	0.00	0	0.00
New Pavement	7,347	0.17	2,102	0.05	23,009	0.53	20,558	0.47	25,395	0.58

Existing	D1			D2			D3			D4		
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		14,489			159,006			128,256			227,285	
		18,811			121,557			107,025				
		818,426			115,077							
		165,572			76,108							
		302,773										
		-10,863										
		86,260										
		45,033										
		68,296										
		335,989										
Total		1,844,786			471,748			235,281			227,285	

Remove & Replace	D1 Stg 1			D2			D3			D4			D1 Stg 2		
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		39,289			2589			17364			9795			7,849	
		30,710									17,243				
Total		69,999			2,589			17,364			27,038			7,849	

New Pavement	D1 Stg 1			D2			D3			D4			D1 Stg 2		
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		5,214			2,102			23,009			8,217			21,096	
		2,133									12,341			4,299	
Total		7,347			2,102			23,009			20,558			25,395	

Remove w/o Replace	D1 Stg 1			D2			D3			D4			D1 Stg 2		
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		7815												0	
Total		7,815			0			0			0			0	

Basin E **NICKEL ST 1 & 2**

E-1	Area (sf)	Area (ac)			
EXISTING					
Basin Area	741,317	17.02			
Impervious	292,924	6.72			
Pervious	448,393	10.29			
PROPOSED					
New Pavement	35,940	0.83			
Remove & Replace	27,703	0.64			
Remove w/o Replace	0	0.00			
Pervious	412,453	9.47			
area check	*741,317*	17.02	*17.0*	*OK*	
change in Perv.	*35,940*	0.83			
Min. Req. 1-4 check	*63,643*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*35,940*	***REQUIRED***			
net new impervious	*35,940*	***REQUIRED***			
50% of Existing Imp.	*146,462*	***EXEMPT***			

E-2	Area (sf)	Area (ac)			
EXISTING					
Basin Area	611,948	14.05			
Impervious	301,499	6.92			
Pervious	310,449	7.13			
PROPOSED					
New Pavement	42,292	0.97			
Remove & Replace	56,620	1.30			
Remove w/o Replace	28,134	0.65			
Pervious	296,291	6.80			
area check	*611,948*	14.05	*14.0*	*OK*	
change in Perv.	*14,158*	0.33			
Min. Req. 1-4 check	*98,912*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*42,292*	***REQUIRED***			
net new impervious	*14,158*	***REQUIRED***			
50% of Existing Imp.	*150,750*	***EXEMPT***			

E-3	Area (sf)	Area (ac)			
EXISTING					
Basin Area	1,064,481	24.44			
Impervious	224,967	5.16			
Pervious	839,514	19.27			
PROPOSED					
New Pavement	0	0.00			
Remove & Replace	0	0.00			
Remove w/o Replace	0	0.00			
Pervious	839,514	19.27			
area check	*1,064,481*	24.44	*24.4*	*OK*	
change in Perv.	*0*	0.00			
Min. Req. 1-4 check	*0*	***EXEMPT***			
Min. Req. 1-9 check					
new impervious	*0*	***EXEMPT***			
net new impervious	*0*	***EXEMPT***			
50% of Existing Imp.	*112,484*	***EXEMPT***			

Calculation of Areas in Drainage Basin E

***uses areas found on S:\000\drainage\kirkland\drawings\kirkland drainage 2J.dgn*

	E1		E2		E3			
	sf	acre	sf	acre	sf	acre	sf	acre
Basin	741,317	17.02	611,948	14.05	1,064,481	24.44		
Existing Impervious	292,924	6.72	301,499	6.92	224,967	5.16		
Remove & Replace	27,703	0.64	56,620	1.30	0	0.00		
Remove w/o Replace	0.0	0.00	28,134	0.65	0	0.00		
New Pavement	35,940	0.83	42,292	0.97	0	0.00		

Existing	E1			E2			E3					
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		292,924			301,499			98,367				
								126,600				
Total		292,924			301,499			224,967			0	

Remove & Replace	E1			E2			E3					
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		27,703			53,949			0				
					2,107							
					564							
Total		27,703			56,620			0			0	

New Pavement	E1			E2			E3					
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		35,940			40,450			0				
					1,502							
					340							
Total		35,940			42,292			0			0	

Remove w/o Replace	E1			E2			E3					
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		0			28,134			0				
Total		0			28,134			0			0	

Basin F **NICKEL ST 1 & 2**

F-1	Area (sf)	Area (ac)			
EXISTING					
Basin Area	570,476	13.10			
Impervious	276,376	6.34			
Pervious	294,100	6.75			
PROPOSED					
New Pavement	9,881	0.23			
Remove & Replace	10,892	0.25			
Remove w/o Replace	1,464	0.03			
Pervious	285,683	6.56			
area check	*570,476*	13.10	*13.1*	*OK*	
change in Perv.	*8,417*	0.19			
Min. Req. 1-4 check	*20,773*	***REQUIRED***			
Min. Req. 1-9 check					
new impervious	*9,881*	***REQUIRED***			
net new impervious	*8,417*	***REQUIRED***			
50% of Existing Imp.	*138,188*	***EXEMPT***			

F-2	Area (sf)	Area (ac)			
EXISTING					
Basin Area	401,284	9.21			
Impervious	229,321	5.26			
Pervious	171,963	3.95			
PROPOSED					
New Pavement	0	0.00			
Remove & Replace	0	0.00			
Remove w/o Replace	0	0.00			
Pervious	171,963	3.95			
area check	*401,284*	9.21	*9.2*	*OK*	
change in Perv.	*0*	0.00			
Min. Req. 1-4 check	*0*	***EXEMPT***			
Min. Req. 1-9 check					
new impervious	*0*	***EXEMPT***			
net new impervious	*0*	***EXEMPT***			
50% of Existing Imp.	*114,661*	***EXEMPT***			

Calculation of Areas in Drainage Basin F

***uses areas found on S:\000\drainage\kirkland\drawings\kirkland drainage 2J.dgn*

	F1		F2		F3		F4	
	sf	acre	sf	acre	sf	acre	sf	acre
Basin	570,476	13.10	401,284	9.21	1,126,038	25.85	750,524	17.23
Existing Impervious	276,376	6.34	229,321	5.26	470,448	10.80	281,970	6.47
Remove & Replace	10,892	0.25	0	0.00	38,643	0.89	1,454	0.03
Remove w/o Replace	1,464	0.03	0	0.00	0	0.00	0	0.00
New Pavement	9,881	0.23	0	0.00	34,626	0.79	0	0.00

Existing	F1			F2			F3			F4		
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		36,539			18,668			9,697			281970	
		25,668			189,406			16,853				
		152,994			21,247			431,192				
								12,706				
		61,175										
Total		276,376			229,321			470,448			281,970	

Remove & Replace	F1			F2			F3					
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		1721						18,299			1454	
		1456						20,344				
		7715										
Total		10,892			0			38,643			1,454	

New Pavement	F1			F2			F3					
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		716						10,131				
		214						24,495				
		8,951										
Total		9,881			0			34,626			0	

Remove w/o Replace	F1			F2			F3					
	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.	sub area	Area (sf)	Area Diff.
		1464										
Total		1,464			0			0			0	

FLOW CONTROL CALCULATION SHEETS
AND
MGS FLOOD PRINTOUTS

Detention Calculation Sheets:

MGSFlood continuous simulation model was used to size detention facilities.

Assumptions:

- Only the new pavement (using WSDOT definition of new pavement) was modeled for detention, disregarding the offsite and other existing impervious flow. The new pavement was modeled as 100% forest in the pre-developed condition and as 100% impervious area in the post-developed condition. This resulted in a detention facility sized to detain only the new pavement area. The existing and offsite flow will be diverted from the flow control facility using a flow splitter allowing only the runoff from the new pavement to be detained in the facility.

- Offsite flow was assumed to be bypassed around the detention facility. In areas where the detention facility could not detain runoff from the new pavement an equivalent area of roadway will be collected and detained.

Flow Control Facilities Table for Kirkland Segment

JH/EM
10/10/2004

				Forested Conditions 100% New Pave							Forested Conditions 100% New Pave						
				Stage 1							Stage 2 (Total Nickel)						
				Detention Volume							Detention Volume						
Location #	Basin Name	MP	STATION	Pave Area Detain (ac)	Length (ft)	Width (ft)	Depth (ft)	Vol (ac-ft)	Side Slope	Area (sf)	Pave Area Detain (ac)	Length (ft)	Width (ft)	Depth (ft)	Vol (ac-ft)	Side Slope	Area (sf)
1	A1	15.89	4009+50 NB								1.08			5	**0.68**	3:1	8,433
2	A2	16.71	4052+50 SB								0.44	120.25	20	5	**0.28**	0	2,405
3	B4	18.22	4132+00 NB	0.35			4	**0.23**	3:1	3,873							
4	C POND	19.10	4179+00 SB	1.66			5	**1.02**	3:1	12,008							
5	C VAULT	19.35 - 19.50	4192+50 SB - 4200+00 SB	4.39	181	60	10	**2.49**	0	10,852	7.95	334	60	10	**4.60**	0	20,032
6	D1	20.16	4325+00 NB	0.17			2.5	**0.11**	3:1	1,917	0.75			2.5	**0.50**	3:1	8,712
7	D3	21.20 - 21.25	4291+00 SB - 4293+00 SB								0.53			4	**0.34****	3:1	3,703
8	D4	21.20 - 21.25	4291+00 SB - 4293+00 SB								0.47			4	**0.26****	3:1	2,831
9	E1	21.96 - 22.01	4331+00 SB - 4334+00 SB								0.83			3	**0.65**	3:1	11,352
10	E2	22.23	4345+00 SB								0.97			3	**0.76**	3:1	13,046
11	F1	22.57	4362+50 NB								0.23			4	**0.15**	3:1	2,736
12	F3	Offsite	E. RIVERSIDE DR.								0.79			4.5	**0.67**	3:1	5,600
Total Detention Per Stage								**3.85**							**8.29**		

*Stage 2 detention amount is the total detention required for the Kirkland nickel project. To get the amount of detention for just stage 2 subtract out stage 1 detention from the value shown in stage 2.
** The detention for D-3 and D-4 will be combined and routed to the existing pond that will be expanded to accommodate the increase in runoff.

S:\000\drainage\Kirkland\New Pave Only 07.13.04\Detention Vault Table - Kirkland 10.21.04
10/21/2004 2:25 PM

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 2:10 PM
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**

Input File Name: A.fld
Project Name : Kirkland Section
Analysis Title: Basin A
Comments :

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.080	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.080	0.000	
SUBBASIN TOTAL	1.080	1.080	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00	ft
Riser Crest Elevation	:	104.50	ft
Maximum Pond Elevation	:	105.00	ft
Maximum Storage Depth	:	4.50	ft
Pond Bottom Length	:	85.4	ft
Pond Bottom Width	:	43.1	ft
Side Slope	:	3.00	ft/ft
Infiltration Rate	:	0.00	in/hr
Pond Bottom Area	:	3680.	sq-ft
Area at Riser Crest El	:	7877.	sq-ft
	:	0.181	acres
Volume at Riser Crest	:	25411.	cu-ft
	:	0.583	ac-ft
Area at Max Elevation	:	8433.	sq-ft
	:	0.194	acres
Volume at Max Elevation	:	29473.	cu-ft
	:	0.677	ac-ft

----------------- Riser Geometry -----------------

Riser Structure Type	:	Circular	
Riser Diameter	:	18.00	in
Common Length	:	0.011	ft
Riser Crest Elevation	:	104.50	ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---

Device Type	:	Circular Orifice	
Invert Elevation	:	100.50	ft
Diameter	:	0.50	in
Orientation	:	Horizontal	
Elbow	:	No	

--- Device Number 2 ---

Device Type	:	Vertical Rectangular Orifice	
Invert Elevation	:	103.22	ft
Length	:	0.1	in
Height	:	15.3	in
Orientation	:	Vertical	
Elbow	:	No	

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************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.012	0.210	
2-Year	0.022	0.275	0.011
5-Year	0.035	0.357	0.023
10-Year	0.045	0.418	0.036
25-Year	0.059	0.504	0.045
50-Year	0.072	0.576	0.051
100-Year	0.085	0.655	0.052
200-Year	0.100	0.740	0.111

* Predeveloped Recurrence Interval Computed Using
Gringorten Plotting Position Due to High Skew Coefficient

* Postdeveloped Recurrence Interval Computed Using
Generalized Extreme Value Distribution

** Computed Using Gringorten Plotting Position

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**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-15.5%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-5.6%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.4%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	1.9%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
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******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 4678. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 7017. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.011 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

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                              MGS FLOOD
                            PROJECT REPORT

Program Version: 2.2.5                          Run Date: 06/14/2004 2:19 PM
********************************************************************************
**

Input File Name: A2.fld
Project Name   :  Kirkland Section
Analysis Title:  Basin A-2 forested
Comments       :  Using forested as 100% predeveloped condition.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040    Puget East 40 in MAP    10/01/1939-10/01/2097
Evaporation Station   : 961040    Puget East 40 in MAP
Evaporation Scale Factor   : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name  : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
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********** Watershed Definition **********
Number of Subbasins:  1


  ********** Subbasin Number: 1 **********
  ***Tributary to Node: 1
  ***Bypass to Node   : None
                  ---------Area(Acres) -------------
                                 ------Developed-----
                  Predeveloped   To Node   Bypass Node   Include GW
Till Forest          0.440        0.000       0.000         No
Till Pasture         0.000        0.000       0.000         No
Till Grass           0.000        0.000       0.000         No
Outwash Forest       0.000        0.000       0.000         No
Outwash Pasture      0.000        0.000       0.000         No
Outwash Grass        0.000        0.000       0.000         No
Wetland              0.000        0.000       0.000         No
Impervious           0.000        0.440       0.000
SUBBASIN TOTAL       0.440        0.440       0.000

 *** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

 *** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99
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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00	ft
Riser Crest Elevation	:	104.50	ft
Maximum Pond Elevation	:	105.00	ft
Maximum Storage Depth	:	4.50	ft
Pond Bottom Length	:	69.4	ft
Pond Bottom Width	:	34.7	ft
Side Slope	:	0.00	ft/ft
Infiltration Rate	:	0.00	in/hr
Pond Bottom Area	:	2405.	sq-ft
Area at Riser Crest El	:	2405.	sq-ft
	:	0.055	acres
Volume at Riser Crest	:	10821.	cu-ft
	:	0.248	ac-ft
Area at Max Elevation	:	2405.	sq-ft
	:	0.055	acres
Volume at Max Elevation	:	12024.	cu-ft
	:	0.276	ac-ft

----------------- Riser Geometry -----------------

Riser Structure Type	:	Circular	
Riser Diameter	:	18.00	in
Common Length	:	0.003	ft
Riser Crest Elevation	:	104.50	ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---

Device Type	:	Circular Orifice	
Invert Elevation	:	100.50	ft
Diameter	:	0.32	in
Orientation	:	Horizontal	
Elbow	:	No	

--- Device Number 2 ---

Device Type	:	Vertical Rectangular Orifice	
Invert Elevation	:	103.02	ft
Length	:	0.0	in
Height	:	17.7	in
Orientation	:	Vertical	
Elbow	:	No	

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************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	3.903E-03	0.068	
2-Year	7.192E-03	0.089	3.461E-03
5-Year	0.011	0.116	7.425E-03
10-Year	0.015	0.135	0.012
25-Year	0.019	0.163	0.015
50-Year	0.023	0.187	0.017
100-Year	0.028	0.212	0.017
200-Year	0.032	0.240	0.039

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

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**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-18.2%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-6.1%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	2.4%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	5.6%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

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****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 1516. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 2274. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.003 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 2:42 PM
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Input File Name: C.fld
Project Name : Kirkland Section
Analysis Title: Basin C1 C2
Comments : Using 100% forested as predeveloped condition.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
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********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.660	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.660	0.000	
SUBBASIN TOTAL	1.660	1.660	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00	ft
Riser Crest Elevation	:	104.50	ft
Maximum Pond Elevation	:	105.00	ft
Maximum Storage Depth	:	4.50	ft
Pond Bottom Length	:	110.7	ft
Pond Bottom Width	:	55.3	ft
Side Slope	:	3.00	ft/ft
Infiltration Rate	:	0.00	in/hr
Pond Bottom Area	:	6127.	sq-ft
Area at Riser Crest El	:	11339.	sq-ft
	:	0.260	acres
Volume at Riser Crest	:	38702.	cu-ft
	:	0.888	ac-ft
Area at Max Elevation	:	12008.	sq-ft
	:	0.276	acres
Volume at Max Elevation	:	44522.	cu-ft
	:	1.022	ac-ft

----------------- Riser Geometry -----------------

Riser Structure Type	:	Circular	
Riser Diameter	:	18.00	in
Common Length	:	0.016	ft
Riser Crest Elevation	:	104.50	ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---

Device Type	:	Circular Orifice	
Invert Elevation	:	100.50	ft
Diameter	:	0.62	in
Orientation	:	Horizontal	
Elbow	:	No	

--- Device Number 2 ---

Device Type	:	Vertical Rectangular Orifice	
Invert Elevation	:	103.19	ft
Length	:	0.2	in
Height	:	15.7	in
Orientation	:	Vertical	
Elbow	:	No	

\
************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.019	0.323	
2-Year	0.034	0.423	0.016
5-Year	0.054	0.548	0.037
10-Year	0.069	0.642	0.056
25-Year	0.091	0.775	0.071
50-Year	0.110	0.886	0.080
100-Year	0.131	1.006	0.082
200-Year	0.154	1.138	0.184

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-12.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-1.1%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	4.3%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	26.9%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
****************** Water Quality Facility Data **************

Basic Wet Pond Volume (91% Exceedance): 7190. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 10785. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.016 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

****

****
MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 2:50 PM
****

Input File Name: C vlt.fld
Project Name : Kirkland Section
Analysis Title: Basin C3 C4 C5 vault forested
Comments : Using 100% forested predeveloped conditions.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
¥
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	4.390	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	4.390	0.000	
SUBBASIN TOTAL	4.390	4.390	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 -------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

¥
********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00	ft
Riser Crest Elevation	:	109.50	ft
Maximum Pond Elevation	:	110.00	ft
Maximum Storage Depth	:	9.50	ft
Pond Bottom Length	:	147.3	ft
Pond Bottom Width	:	73.7	ft
Side Slope	:	0.00	ft/ft
Infiltration Rate	:	0.00	in/hr
Pond Bottom Area	:	10852.	sq-ft
Area at Riser Crest El	:	10852.	sq-ft
	:	0.249	acres
Volume at Riser Crest	:	103096.	cu-ft
	:	2.367	ac-ft
Area at Max Elevation	:	10852.	sq-ft
	:	0.249	acres
Volume at Max Elevation	:	108522.	cu-ft
	:	2.491	ac-ft

----------------- Riser Geometry -----------------

Riser Structure Type	:	Circular	
Riser Diameter	:	18.00	in
Common Length	:	0.010	ft
Riser Crest Elevation	:	109.50	ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---

Device Type	:	Circular Orifice	
Invert Elevation	:	100.50	ft
Diameter	:	0.84	in
Orientation	:	Horizontal	

Elbow : No

--- Device Number 2 ---

Device Type : Vertical Rectangular Orifice
Invert Elevation : 106.17 ft
Length : 0.1 in
Height : 40.0 in
Orientation : Vertical
Elbow : No

¥

************* Flow Frequency Data for Selected Recurrence Intervals ************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.049	0.853	
2-Year	0.090	1.118	0.043
5-Year	0.143	1.450	0.097
10-Year	0.183	1.698	0.146
25-Year	0.242	2.051	0.189
50-Year	0.291	2.342	0.214
100-Year	0.345	2.660	0.238
200-Year	0.406	3.008	0.480

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

¥

**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped λQ2 (Must be Less Than 0%): -11.6% PASS
Maximum Excursion from λQ2 to Q2 (Must be Less Than 0%): -7.1% PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 1.2% PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 2.8% PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

¥

****************** Water Quality Facility Data **************

Basic Wet Pond Volume (91% Exceedance): 19015. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 28522. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.043 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 2:58 PM
****

Input File Name: C vlt2.fld
Project Name : Kirkland Section
Analysis Title: Basin C vault stage 2
Comments : Using 100% forested predeveloped conditions stage 2.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
¥
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	7.950	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	7.950	0.000	
SUBBASIN TOTAL	7.950	7.950	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

¥
********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00	ft
Riser Crest Elevation	:	109.50	ft
Maximum Pond Elevation	:	110.00	ft
Maximum Storage Depth	:	9.50	ft
Pond Bottom Length	:	200.2	ft
Pond Bottom Width	:	100.1	ft
Side Slope	:	0.00	ft/ft
Infiltration Rate	:	0.00	in/hr
Pond Bottom Area	:	20032.	sq-ft
Area at Riser Crest El	:	20032.	sq-ft
	:	0.460	acres
Volume at Riser Crest	:	190301.	cu-ft
	:	4.369	ac-ft
Area at Max Elevation	:	20032.	sq-ft
	:	0.460	acres
Volume at Max Elevation	:	200317.	cu-ft
	:	4.599	ac-ft

----------------- Riser Geometry -----------------

Riser Structure Type	:	Circular	
Riser Diameter	:	18.00	in
Common Length	:	0.021	ft
Riser Crest Elevation	:	109.50	ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---

Device Type	:	Circular Orifice	
Invert Elevation	:	100.50	ft
Diameter	:	1.13	in
Orientation	:	Horizontal	

Elbow : No

--- Device Number 2 ---

Device Type	: Vertical Rectangular Orifice		
Invert Elevation	:	106.11	ft
Length	:	0.2	in
Height	:	40.7	in
Orientation	: Vertical		
Elbow	: No		

¥

************* Flow Frequency Data for Selected Recurrence Intervals ************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.089	1.545	
2-Year	0.163	2.025	0.078
5-Year	0.259	2.625	0.180
10-Year	0.332	3.075	0.270
25-Year	0.438	3.713	0.354
50-Year	0.527	4.242	0.404
100-Year	0.626	4.818	0.420
200-Year	0.735	5.448	0.547

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

¥

**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped λQ2 (Must be Less Than 0%):	-14.0%	PASS
Maximum Excursion from λQ2 to Q2 (Must be Less Than 0%):	-5.4%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	9.5%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	25.9%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

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****************** Water Quality Facility Data **************

Basic Wet Pond Volume (91% Exceedance): 34434. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 51651. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.078 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

HNTB The HNTB Companies	Made by ERM	Date 8/2/04	Job Number
	Checked by	Date	Sheet Number
Calculations For	Backchecked by	Date	

SIZING OF VAULT SECTIONS

FOR SECTION 1 + 2

- AREA OF PAVEMENT TO BE DETAINED

C.4 = 2.86 AC   SEE WQ AREA DWGS
C.6A = 1.97 AC
4.83 AC

FOR SECTION 3

- AREA OF PAVEMENT TO BE DETAINED

7.95 AC OF NEW PAVEMENT FOR NICKEL
− 4.83 AC DETAINED IN VAULT SEC 1+2
3.12 AC NEED FOR DETENTION IN SEC 3

VAULT DETENTION VOL. NEEDED FROM MGS FLOOD TO DETAIN TOTAL NICKEL = 4.60 AC-FT
SECTION 1 + 2 DETENTION FOR 4.83 AC FROM MGS FLOOD = 2.75 AC-FT
VOLUME NEEDED TO BE DETAINED IN SECTION 3 = 1.85 AC-FT

SIZING

SECTION 1 + 2 = 10' x 40' x 300' = 2.75 AC-FT
SECTION 3 = 10' x 20' x 403' = 1.85 AC-FT

TOTAL DETENTION = 4.60 AC-FT

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**

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 07/30/2004 8:37 AM
****
**

Input File Name: valut 1&2.fld
Project Name : Kirkland Section
Analysis Title: Vault section 1 and 2
Comments : Sizing for section 1 and 2 c.6a and c.4

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	4.830	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	4.830	0.000	
SUBBASIN TOTAL	4.830	4.830	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00	ft
Riser Crest Elevation	:	109.50	ft
Maximum Pond Elevation	:	110.00	ft
Maximum Storage Depth	:	9.50	ft
Pond Bottom Length	:	189.5	ft
Pond Bottom Width	:	63.2	ft
Side Slope	:	0.00	ft/ft
Infiltration Rate	:	0.00	in/hr
Pond Bottom Area	:	11965.	sq-ft
Area at Riser Crest El	:	11965.	sq-ft
	:	0.275	acres
Volume at Riser Crest	:	113667.	cu-ft
	:	2.609	ac-ft
Area at Max Elevation	:	11965.	sq-ft
	:	0.275	acres
Volume at Max Elevation	:	119649.	cu-ft
	:	2.747	ac-ft

----------------- Riser Geometry -----------------

Riser Structure Type	:	Circular	
Riser Diameter	:	18.00	in
Common Length	:	0.011	ft
Riser Crest Elevation	:	109.50	ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---

Device Type	:	Circular Orifice	
Invert Elevation	:	100.50	ft
Diameter	:	0.88	in
Orientation	:	Horizontal	
Elbow	:	No	

--- Device Number 2 ---

Device Type	:	Vertical Rectangular Orifice	
Invert Elevation	:	106.17	ft
Length	:	0.1	in
Height	:	40.0	in
Orientation	:	Vertical	
Elbow	:	No	

\
************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.054	0.938	
2-Year	0.099	1.230	0.048
5-Year	0.157	1.595	0.106
10-Year	0.202	1.868	0.161
25-Year	0.266	2.256	0.207
50-Year	0.320	2.577	0.235
100-Year	0.380	2.927	0.246
200-Year	0.447	3.310	0.502

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-11.9%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-7.4%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.4%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	1.9%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

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****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 20920. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 31381. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.048 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 3:06 PM
****
**

Input File Name: D1.fld
Project Name : Kirkland Section
Analysis Title: Basin D-1 forested
Comments : Using 100% forested predeveloped condition. stage 1

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
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********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.170	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	0.170	0.000	
SUBBASIN TOTAL	0.170	0.170	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

 ----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation     :    100.00   ft
Riser Crest Elevation    :    103.50   ft
Maximum Pond Elevation   :    104.00   ft
Maximum Storage Depth    :      3.50   ft
Pond Bottom Length       :     30.5    ft
Pond Bottom Width        :     15.3    ft
Side Slope               :      3.00   ft/ft
Infiltration Rate        :      0.00   in/hr
Pond Bottom Area         :    466.     sq-ft
Area at Riser Crest El   :   1868.     sq-ft
                         :     0.043   acres
Volume at Riser Crest    :   3812.     cu-ft
                         :    0.088    ac-ft
Area at Max Elevation    :   2141.     sq-ft
                         :     0.049   acres
Volume at Max Elevation:     4807.     cu-ft
                         :    0.110    ac-ft

 ----------------- Riser Geometry -----------------
Riser Structure Type     : Circular
Riser Diameter           : 18.00       in
Common Length            : 0.003       ft
Riser Crest Elevation    : 103.50      ft

  ---------- Hydraulic Structure Geometry -----------

Number of Devices:    3

      --- Device Number   1 ---
Device Type            :  Circular Orifice
Invert Elevation       :   100.50        ft
Diameter               :   0.21          in
Orientation            : Horizontal
Elbow                  : No

      --- Device Number   2 ---
Device Type            : Vertical Rectangular Orifice
Invert Elevation       :   102.68        ft
Length                 :     0.0         in
Height                 :     9.8         in
Orientation            : Vertical
Elbow                  : No
```

\
************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	1.896E-03	0.033	
2-Year	3.493E-03	0.043	1.689E-03
5-Year	5.537E-03	0.056	3.385E-03
10-Year	7.103E-03	0.066	5.403E-03
25-Year	9.363E-03	0.079	6.567E-03
50-Year	0.011	0.091	7.349E-03
100-Year	0.013	0.103	7.364E-03
200-Year	0.016	0.116	0.023

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-15.9%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-13.2%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-10.7%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 736. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 1104. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.002 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

****

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 3:13 PM

****

Input File Name: D1 st2.fld
Project Name : Kirkland Section
Analysis Title: Basin D-1 stage 2
Comments : Using 100 % forested predeveloped condition. Stage 2.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.750	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	0.750	0.000	
SUBBASIN TOTAL	0.750	0.750	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00	ft
Riser Crest Elevation	:	103.50	ft
Maximum Pond Elevation	:	104.00	ft
Maximum Storage Depth	:	3.50	ft
Pond Bottom Length	:	86.0	ft
Pond Bottom Width	:	43.0	ft
Side Slope	:	3.00	ft/ft
Infiltration Rate	:	0.00	in/hr
Pond Bottom Area	:	3701.	sq-ft
Area at Riser Crest El	:	6852.	sq-ft
	:	0.157	acres
Volume at Riser Crest	:	18187.	cu-ft
	:	0.418	ac-ft
Area at Max Elevation	:	7374.	sq-ft
	:	0.169	acres
Volume at Max Elevation	:	21732.	cu-ft
	:	0.499	ac-ft

----------------- Riser Geometry -----------------

Riser Structure Type	:	Circular	
Riser Diameter	:	18.00	in
Common Length	:	0.012	ft
Riser Crest Elevation	:	103.50	ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---

Device Type	:	Circular Orifice	
Invert Elevation	:	100.50	ft
Diameter	:	0.45	in
Orientation	:	Horizontal	
Elbow	:	No	

--- Device Number 2 ---

Device Type	:	Vertical Rectangular Orifice	
Invert Elevation	:	102.51	ft
Length	:	0.1	in
Height	:	11.9	in
Orientation	:	Vertical	
Elbow	:	No	

\
************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	8.364E-03	0.146	
2-Year	0.015	0.191	7.401E-03
5-Year	0.024	0.248	0.017
10-Year	0.031	0.290	0.026
25-Year	0.041	0.350	0.033
50-Year	0.050	0.400	0.037
100-Year	0.059	0.455	0.038
200-Year	0.069	0.514	0.083

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-14.5%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-1.9%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	7.8%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	33.3%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

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******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 3249. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 4873. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.007 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 3:25 PM

****

Input File Name: D3 D~~2~~.fld
Project Name : Kirkland Section
Analysis Title: Basin D3
Comments : Using 100% forested as predeveloped condition.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
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********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.530	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	0.530	0.000	
SUBBASIN TOTAL	0.530	0.530	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00	ft
Riser Crest Elevation	:	103.50	ft
Maximum Pond Elevation	:	104.00	ft
Maximum Storage Depth	:	3.50	ft
Pond Bottom Length	:	68.1	ft
Pond Bottom Width	:	34.1	ft
Side Slope	:	3.00	ft/ft
Infiltration Rate	:	0.00	in/hr
Pond Bottom Area	:	2320.	sq-ft
Area at Riser Crest El	:	4906.	sq-ft
	:	0.113	acres
Volume at Riser Crest	:	12366.	cu-ft
	:	0.284	ac-ft
Area at Max Elevation	:	5348.	sq-ft
	:	0.123	acres
Volume at Max Elevation	:	14920.	cu-ft
	:	0.343	ac-ft

----------------- Riser Geometry -----------------

Riser Structure Type	:	Circular	
Riser Diameter	:	18.00	in
Common Length	:	0.008	ft
Riser Crest Elevation	:	103.50	ft

---------- Hydraulic Structure Geometry ----------

Number of Devices: 3

--- Device Number 1 ---

Device Type	:	Circular Orifice	
Invert Elevation	:	100.50	ft
Diameter	:	0.37	in
Orientation	:	Horizontal	
Elbow	:	No	

--- Device Number 2 ---

Device Type	:	Vertical Rectangular Orifice	
Invert Elevation	:	102.56	ft
Length	:	0.1	in
Height	:	11.3	in
Orientation	:	Vertical	
Elbow	:	No	

\
************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	5.910E-03	0.103	
2-Year	0.011	0.135	5.260E-03
5-Year	0.017	0.175	0.012
10-Year	0.022	0.205	0.018
25-Year	0.029	0.248	0.023
50-Year	0.035	0.283	0.026
100-Year	0.042	0.321	0.034
200-Year	0.049	0.363	0.074

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-13.2%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-0.3%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	6.9%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	34.3%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

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******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 2296. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 3443. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.005 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 3:33 PM
****
**

Input File Name: D4.fld
Project Name : Kirkland Section
Analysis Title: Basin D4
Comments : Using 100% forested as predeveloped.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.470	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	0.470	0.000	
SUBBASIN TOTAL	0.470	0.470	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

\

********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation	:	100.00	ft
Riser Crest Elevation	:	106.00	ft
Maximum Pond Elevation	:	106.50	ft
Maximum Storage Depth	:	6.00	ft
Pond Bottom Length	:	28.8	ft
Pond Bottom Width	:	14.4	ft
Side Slope	:	3.00	ft/ft
Infiltration Rate	:	0.00	in/hr
Pond Bottom Area	:	414.	sq-ft
Area at Riser Crest El	:	3265.	sq-ft
	:	0.075	acres
Volume at Riser Crest	:	9686.	cu-ft
	:	0.222	ac-ft
Area at Max Elevation	:	3620.	sq-ft
	:	0.083	acres
Volume at Max Elevation	:	11394.	cu-ft
	:	0.262	ac-ft

----------------- Riser Geometry -----------------

Riser Structure Type	:	Circular	
Riser Diameter	:	18.00	in
Common Length	:	0.004	ft
Riser Crest Elevation	:	106.00	ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---

Device Type	:	Circular Orifice	
Invert Elevation	:	100.50	ft
Diameter	:	0.30	in
Orientation	:	Horizontal	
Elbow	:	No	

--- Device Number 2 ---

Device Type	:	Vertical Rectangular Orifice	
Invert Elevation	:	104.61	ft
Length	:	0.0	in
Height	:	16.7	in
Orientation	:	Vertical	
Elbow	:	No	

\
************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	5.241E-03	0.091	
2-Year	9.657E-03	0.120	4.713E-03
5-Year	0.015	0.155	0.010
10-Year	0.020	0.182	0.016
25-Year	0.026	0.220	0.019
50-Year	0.031	0.251	0.021
100-Year	0.037	0.285	0.021
200-Year	0.043	0.322	0.081

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-15.7%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-3.7%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-2.3%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
****************** Water Quality Facility Data **************

Basic Wet Pond Volume (91% Exceedance): 2036. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 3054. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.005 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

****

COMBINED BASINS TDA-D3/D4

TOTAL AREA

- TDA-D3: 19.56-AC
- TDA-D4: 15.29-AC

COMBINED D3/D4: 34.85-AC

IMPERVIOUS AREA

- TDA-D3: 5.40-AC
- TDA-D4: 5.22-AC

COMBINED D3/D4: 10.62-AC

PERVIOUS AREA

- TDA-D3: 14.16-AC
- TDA-D4: 10.07-AC

COMBINED D3/D4: 24.23-AC

NET-NEW IMPERVIOUS AREA

- TDA-D3: 0.53-AC
- TDA-D4: 0.47-AC

COMBINED D3/D4: 1.00-AC

ADD IN PROPOSED POND AREA: 7048-SF @ RISER CREST = 0.16-AC

ADJUSTED NET-NEW IMPERVIOUS: 1.16-AC

(SEE REPORT PRINT-OUT: D3 D4 Combined.fld)

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 10/05/2004 8:02 AM

****

Input File Name: D3 D4 Combined.fld
Project Name : Kirkland Nickel
Analysis Title: Combined Basins TDA-D3/D4
Comments : Basins combined for pond expansion

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.160	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.160	0.000	
SUBBASIN TOTAL	1.160	1.160	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation : 100.00 ft
Riser Crest Elevation : 104.00 ft
Maximum Pond Elevation : 104.50 ft
Maximum Storage Depth : 4.00 ft
Pond Bottom Length : 128.1 ft
Pond Bottom Width : 32.0 ft
Side Slope : 3.00 ft/ft
Infiltration Rate : 0.00 in/hr
Pond Bottom Area : 4099. sq-ft
Area at Riser Crest El : 8517. sq-ft
: 0.196 acres
Volume at Riser Crest : 24700. cu-ft
: 0.567 ac-ft
Area at Max Elevation : 9150. sq-ft
: 0.210 acres
Volume at Max Elevation: 29061. cu-ft
: 0.667 ac-ft

----------------- Riser Geometry -----------------
Riser Structure Type : Circular
Riser Diameter : 18.00 in
Common Length : 0.012 ft
Riser Crest Elevation : 104.00 ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---
Device Type : Circular Orifice
Invert Elevation : 100.00 ft
Diameter : 0.51 in
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---

Device Type : Vertical Rectangular Orifice
Invert Elevation : 102.75 ft
Length : 0.1 in
Height : 15.0 in
Orientation : Vertical
Elbow : No

************** Flow Frequency Data for Selected Recurrence Intervals *************

	Subbasin 1 Runoff Predevelopment*	Subbasin 1 Runoff Postdevelopment*	Pond Outflow Node Postdevelopment**
Tr (Years)	Flow(cfs)	Flow(cfs)	Flow(cfs)
6-Month	0.013	0.225	
2-Year	0.024	0.295	0.011
5-Year	0.038	0.383	0.026
10-Year	0.048	0.449	0.039
25-Year	0.064	0.542	0.050
50-Year	0.077	0.619	0.057
100-Year	0.091	0.703	0.058
200-Year	0.107	0.795	0.127

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

**** Flow Duration Performance According to Dept. of Ecology Criteria ****
Excursion at Predeveloped ½Q2 (Must be Less Than 0%): -15.4% PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%): -1.6% PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 7.2% PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 33.3% PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 5024. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 7537. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.011 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

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*******************************************************************************
**
                              MGS FLOOD
                            PROJECT REPORT

Program Version: 2.2.5                        Run Date: 06/14/2004 3:43 PM
*******************************************************************************
**

Input File Name: E1.fld
Project Name  :  Kirkland Section
Analysis Title:  Basin E1
Comments      :  Using 100% forested predeveloped conditions.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040    Puget East 40 in MAP     10/01/1939-10/01/2097
Evaporation Station   : 961040    Puget East 40 in MAP
Evaporation Scale Factor   : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name  : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins:  1


 ********** Subbasin Number: 1 **********
 ***Tributary to Node: 1
 ***Bypass to Node   : None
                  ---------Area(Acres) -------------
                                ------Developed-----
                  Predeveloped  To Node  Bypass Node  Include GW
Till Forest          0.830       0.000        0.000      No
Till Pasture         0.000       0.000        0.000      No
Till Grass           0.000       0.000        0.000      No
Outwash Forest       0.000       0.000        0.000      No
Outwash Pasture      0.000       0.000        0.000      No
Outwash Grass        0.000       0.000        0.000      No
Wetland              0.000       0.000        0.000      No
Impervious           0.000       0.830        0.000
SUBBASIN TOTAL       0.830       0.830        0.000

 *** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

 *** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99
```

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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

 ----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation     :    100.00   ft
Riser Crest Elevation    :    102.50   ft
Maximum Pond Elevation   :    103.00   ft
Maximum Storage Depth    :      2.50   ft
Pond Bottom Length       :     123.9   ft
Pond Bottom Width        :      62.0   ft
Side Slope               :      3.00   ft/ft
Infiltration Rate        :      0.00   in/hr
Pond Bottom Area         :     7681.   sq-ft
Area at Riser Crest El   :    10695.   sq-ft
                         :     0.246   acres
Volume at Riser Crest    :    22867.   cu-ft
                         :    0.525    ac-ft
Area at Max Elevation    :    11352.   sq-ft
                         :     0.261   acres
Volume at Max Elevation:      28371.   cu-ft
                         :    0.651    ac-ft

 ----------------- Riser Geometry -----------------
Riser Structure Type     : Circular
Riser Diameter           : 18.00       in
Common Length            : 0.023       ft
Riser Crest Elevation    : 102.50      ft

  ---------- Hydraulic Structure Geometry -----------

Number of Devices:     3

      --- Device Number   1 ---
Device Type           :  Circular Orifice
Invert Elevation      :   100.50          ft
Diameter              :   0.53            in
Orientation           : Horizontal
Elbow                 : No

      --- Device Number   2 ---
Device Type           : Vertical Rectangular Orifice
Invert Elevation      :   101.80          ft
Length                :     0.3           in
Height                :     8.4           in
Orientation           : Vertical
Elbow                 : No
```

\
************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	9.256E-03	0.161	
2-Year	0.017	0.211	8.111E-03
5-Year	0.027	0.274	0.018
10-Year	0.035	0.321	0.028
25-Year	0.046	0.388	0.036
50-Year	0.055	0.443	0.041
100-Year	0.065	0.503	0.042
200-Year	0.077	0.569	0.045

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

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**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-17.5%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-8.1%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	2.9%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	8.4%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
****************** Water Quality Facility Data **************

Basic Wet Pond Volume (91% Exceedance): 3595. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 5393. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.008 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 3:50 PM
****
**

Input File Name: E2.fld
Project Name : Kirkland Section
Analysis Title: Basin E2
Comments : Using 100% forested as predeveloped.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.970	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	0.970	0.000	
SUBBASIN TOTAL	0.970	0.970	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

 ----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation     :    100.00   ft
Riser Crest Elevation    :    102.50   ft
Maximum Pond Elevation   :    103.00   ft
Maximum Storage Depth    :      2.50   ft
Pond Bottom Length       :     134.8   ft
Pond Bottom Width        :     67.4    ft
Side Slope               :      3.00   ft/ft
Infiltration Rate        :      0.00   in/hr
Pond Bottom Area         :    9083.    sq-ft
Area at Riser Crest El   :    12340.   sq-ft
                         :     0.283   acres
Volume at Riser Crest    :    26675.   cu-ft
                         :    0.612    ac-ft
Area at Max Elevation    :    13046.   sq-ft
                         :     0.299   acres
Volume at Max Elevation:      33014.   cu-ft
                         :    0.758    ac-ft

 ----------------- Riser Geometry -----------------
Riser Structure Type     : Circular
Riser Diameter           : 18.00       in
Common Length            : 0.026       ft
Riser Crest Elevation    : 102.50      ft

  ---------- Hydraulic Structure Geometry -----------

Number of Devices:    3

      --- Device Number   1 ---
Device Type           :  Circular Orifice
Invert Elevation      :   100.50         ft
Diameter              :   0.57           in
Orientation           : Horizontal
Elbow                 : No

      --- Device Number   2 ---
Device Type           : Vertical Rectangular Orifice
Invert Elevation      :   101.79         ft
Length                :     0.3          in
Height                :     8.5          in
Orientation           : Vertical
Elbow                 : No
```

\
************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.011	0.188	
2-Year	0.020	0.247	9.485E-03
5-Year	0.032	0.320	0.021
10-Year	0.041	0.375	0.033
25-Year	0.053	0.453	0.042
50-Year	0.064	0.518	0.047
100-Year	0.076	0.588	0.049
200-Year	0.090	0.665	0.058

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-15.4%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-6.4%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	3.7%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	9.3%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

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****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 4201. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 6302. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.009 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

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**

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/14/2004 3:57 PM
****
**

Input File Name: F1.fld
Project Name : Kirkland Section
Analysis Title: Basin F1
Comments : Using 100% forested predeveloped condition.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
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********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.230	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	0.230	0.000	
SUBBASIN TOTAL	0.230	0.230	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

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********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

----------------- Pond Geometry -----------------

Prismatic Pond Option Used

```
Pond Floor Elevation     :    100.00   ft
Riser Crest Elevation    :    103.50   ft
Maximum Pond Elevation   :    104.00   ft
Maximum Storage Depth    :      3.50   ft
Pond Bottom Length       :     38.9    ft
Pond Bottom Width        :     19.5    ft
Side Slope               :      3.00   ft/ft
Infiltration Rate        :      0.00   in/hr
Pond Bottom Area         :    758.     sq-ft
Area at Riser Crest El   :   2426.     sq-ft
                         :     0.056   acres
Volume at Riser Crest    :   5297.     cu-ft
                         :    0.122    ac-ft
Area at Max Elevation    :   2736.     sq-ft
                         :     0.063   acres
Volume at Max Elevation:     6580.     cu-ft
                         :    0.151    ac-ft
```

----------------- Riser Geometry -----------------

```
Riser Structure Type     : Circular
Riser Diameter           : 18.00        in
Common Length            : 0.004        ft
Riser Crest Elevation    : 103.50       ft
```

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number   1 ---

```
Device Type          :  Circular Orifice
Invert Elevation     :   100.50          ft
Diameter             :   0.24            in
Orientation          : Horizontal
Elbow                : No
```

--- Device Number   2 ---

```
Device Type          : Vertical Rectangular Orifice
Invert Elevation     :   102.62          ft
Length               :     0.0           in
Height               :     10.5          in
Orientation          : Vertical
Elbow                : No
```

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************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	2.565E-03	0.045	
2-Year	4.726E-03	0.059	2.281E-03
5-Year	7.492E-03	0.076	4.820E-03
10-Year	9.611E-03	0.089	7.660E-03
25-Year	0.013	0.107	9.527E-03
50-Year	0.015	0.123	0.011
100-Year	0.018	0.139	0.011
200-Year	0.021	0.158	0.033

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-17.4%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-6.8%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-1.9%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 996. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 1494. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.002 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

****

Combined Wetland / Detention Pond Sizing for TDA-F3 / TDA-F4

Surface Area of Wetland Cell = Top Area of Wet Pond

3422-cf / 3-ft depth = 1141-sf

Size Presettling in Retention/Detention Pond:

For sizing: assume forbay = 25% wet pool volume

3422-cf x (0.25) / 4-ft depth = 214-sf

Volume => 3422-cf (0.25) = 856-cf

Size Second Cell of Retention/Detention Pond:

Total Required Detention Volume (Max Stage) = 21,752-cf

Volume required for second cell => 21752-cf - 856-cf = 20,896-cf

Area of second cell: assume depth of 5-ft; Surface area = approx. 4,180-sf

Surface Area of Wetland Cell:

1141-sf - 214-sf = 927-sf

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/15/2004 8:12 AM
****

Input File Name: F3.fld
Project Name : Kirkland Section
Analysis Title: Basin F3 – Detention Sizing for Combined Detention/Wetland Facility
Comments : Using 100% forested predeveloped condition

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) ------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.790	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	0.790	0.000	
SUBBASIN TOTAL	0.790	0.790	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 -------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

---------------- Pond Geometry ----------------

Prismatic Pond Option Used

Pond Floor Elevation : 100.00 ft
Riser Crest Elevation : 104.50 ft
Maximum Pond Elevation : 105.00 ft
Maximum Storage Depth : 4.50 ft
Pond Bottom Length : 70.4 ft
Pond Bottom Width : 35.2 ft
Side Slope : 3.00 ft/ft
Infiltration Rate : 0.00 in/hr
Pond Bottom Area : 2478. sq-ft
Area at Riser Crest El : 6058. sq-ft
: 0.139 acres
Volume at Riser Crest : 18616. cu-ft
: 0.427 ac-ft
Area at Max Elevation : 6546. sq-ft
: 0.150 acres
Volume at Max Elevation: 21752. cu-ft
: 0.499 ac-ft

---------------- Riser Geometry ----------------
Riser Structure Type : Circular
Riser Diameter : 18.00 in
Common Length : 0.008 ft
Riser Crest Elevation : 104.50 ft

---------- Hydraulic Structure Geometry ----------

Number of Devices: 3

--- Device Number 1 ---
Device Type : Circular Orifice
Invert Elevation : 100.50 ft
Diameter : 0.43 in

Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Invert Elevation : 103.21 ft
Length : 0.1 in
Height : 15.5 in
Orientation : Vertical
Elbow : No

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	8.810E-03	0.153	
2-Year	0.016	0.201	7.832E-03
5-Year	0.026	0.261	0.017
10-Year	0.033	0.306	0.026
25-Year	0.044	0.369	0.033
50-Year	0.052	0.422	0.037
100-Year	0.062	0.479	0.037
200-Year	0.073	0.541	0.064

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

**** Flow Duration Performance According to Dept. of Ecology Criteria ****
Excursion at Predeveloped ½Q2 (Must be Less Than 0%): -13.6% PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%): -4.6% PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): -1.7% PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0% PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 3422. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 5133. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.008 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

RUNOFF TREATMENT (WATER QUALITY) CALCULATIONS

Water Quality Calculation Sheets:

MGSFlood continuous simulation model was used to size water quality facilities.

Assumptions:

Ecology Embankment

- Ecology embankment sizes were calculated based on formulas taken from the WSDOT HRM March 2004 pg 5-75.
- The Q_{hwy} used in calculating ecology embankments was found from the 15 minute time step water quality flow rate as calculated by MGSFlood.
- The effective impervious areas were used to size the ecology embankments to provide treatment to all runoff that will flow onto the embankment. This resulted in a higher percentage of water quality treatment than the minimum requirements.
- No detention in the drain rock was accounted for in the ecology embankments.
- It was assumed the ecology embankment would have a minimum vegetated ecology mix area width of 4 feet. Due to this assumption, many of the basins have more water quality treatment than required.

Water Quality Wetland

- Water Quality Wetlands were sized based on formulas from the WSDOT HRM March 2004 pg 5-93.

Table of Runoff Treatment Facilities for Kirkland Segment

Made by: JH/EM
Date: 10/20/2004

Basin Name	Facility #	MP to MP	Station	Drainage Area (ac)	Facility Type	Facility Size Length(L) (ft)	Facility Size Width (W) (ft)	Contributing EIS Area (ac)	New Pavement Area (ac)	% of WQ Treat. Provided	Detention Depth (ft)	Detention Vol (ac-ft)
A1	A1.1	15.89 - 16.22	4012+50 SB - 4027+00 NB	1.11	ECO-EMBKMT	1438	4	1.11	1.08	193%	NA	NA
A1	A1.1	16.28 - 16.57	4030+00 SB - 4045+00 SB	0.97	ECO-EMBKMT	1541	4	0.97			NA	NA
A2	A2.1	16.57 - 16.69	4045+00 SB - 4052+00 SB	0.73	ECO-EMBKMT	633	4	0.73	0.44	316%	NA	NA
A2	A2.2	16.83 - 16.84	4053+00 SB - 4059+50 SB	0.66	ECO-EMBKMT	579	4	0.66			NA	NA
B4	B4.1	18.16 - 18.25	4129+50 NB - 4134+50 NB	1.28	ECO-EMBKMT	466	4	1.28	0.35	863%	NA	NA
B4	B4.2	18.34 - 18.58	4139+00 NB - 4151+00 NB	1.74	ECO-EMBKMT	1245	4	1.74			NA	NA
C1	C1.1	18.58 - 19.36	4151+50 SB - 4192+50 SB	8.23	ECO-EMBKMT	4111	4	8.23	9.61	130%	NA	NA
C1	C1.2	19.10 - 19.60	4179+00 NB - 4205+00 NB	4.24	ECO-EMBKMT	2584	4	4.24			NA	NA
D1	D1.1	19.85 - 19.95	4219+00 SB - 4224+00 SB	0.81	ECO-EMBKMT	490	4	3.69	0.75	492%	NA	NA
D3	D3.1	21.03 - 21.53	4281+00 SB - 4308+00 SB	3.50	ECO-EMBKMT	1790	4	3.50	0.53	660%	NA	NA
D4	D4.1	21.49- 21.77	4305+50 SB - 4321+00 SB	1.85	ECO-DITCH	1533	4	1.85	0.47	664%	NA	NA
D4	D4.2	21.54 - 21.56	4308+50 SB - 4310+00 SB	1.27	ECO-EMBKMT	815	4	1.27			NA	NA
E1	E1.1	21.77 - 22.17	4321+00 SB - 4342+00 SB	2.99	ECO-EMBKMT	2080	4	2.99	0.83	360%	NA	NA
E2	E2.1	22.17 - 22.45	4342+00 SB - 4357+00 SB	2.41	ECO-EMBKMT	1496	4	2.41	0.97	413%	NA	NA
E2	E2.2	22.30 - 22.47	4349+00 SB - 4358+00 SB	1.60	ECO-DITCH	900	4	1.60			NA	NA
F1	F1.1	22.47 - 22.56	4358+00 SB - 4362+50 SB	0.61	ECO-EMBKMT	447	4	1.48	0.23	643%	NA	NA
F3	F3.1	OFFSITE	E. RIVERSIDE DR.	1.68	WETLAND	NA	NA	13.98	0.79	1770%	2	0.06
Total Kirkland Section Water Quality Treatment								51.73	16.05	322%		

* Facility size area is calculated as length of Ecology Embankment mulitiplied by 4 feet (minimum width of Ecology Embankment per HRM)
** Total minimum required area for the entire basin. These basins may be split into more than one ecology embankment.

HNTB The HNTB Companies	Made by ERM	Date 9/17/04	Job Number
	Checked by	Date	Sheet Number
For KIRKLAND NICKEL ECO EMBANK.	Backchecked by	Date	

ECOLOGY EMBANKMENT SIZING (HRM PG 5-75)

$$Q_{highway} < Q_{INFILTRATION}$$

$Q_{highway}$ = MGSFLOOD WQ FLOWRATE (CHANGE IN FORMULA AS STATED BY ALEX NGUYEN WSDOT)

$$Q_{HIGHWAY} = (LTIR_{ECO})(WIDTH_{ECO})$$

$WIDTH_{ECO}$ = WIDTH OF ECOLOGY EMBANKMENT
LTIR = LONG TERM INFILTRATON RATE OF ECOLOGY MIX = 14 inches/hr

$$WIDTH_{ECO} = \frac{Q_{HIGHWAY}}{LTIR_{ECO}}$$

$$WIDTH_{ECO} = \frac{Q_{HIGHWAY}}{14\ in/hr}$$

$$WIDTH_{ECO}(ft^2) = \frac{Q_{HIGHWAY}\ (ft^3/s)}{0.000324\ (ft^3/s)}$$

- ROUND WIDTH TO NEAREST FOOT WITH A MINIMUM WIDTH OF 4' (AS DETERMINED BY KIRKLAND DRAINAGE TEAM)

ME101-0793

Ecology Embankment Design Calcs.

Calculation formulas revised 6/26/04

Basin Name	A1 Equivalent Area
Effective Impervious Area (EIS) (acres)	4.18
Length of Pavement To WQ Treat (ft)	3288
MGS Online Flow (cfs)	0.75
MGS Offline Flow (cfs)	0.43

<u>Ecology Embankment Size</u>

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to cfs 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	2,314.8	2,315
Offline Ecology Embankment Area Needed (sf)	1,327.16	1,327

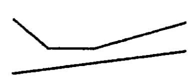
If Length of ditch is assumed to be equal to pavement length enter length of pavement to be treated via sheet flow

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	0.70	[illegible]
Offline Ecology Ditch bottom width (ft)	0.40	4

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	578.75 LF

<u>Ecology Ditch Design Req. (HRM pg 5-66)</u>



slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

****
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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/29/2004 7:11 PM
****
**

Input File Name: A1 eco equiv.fld
Project Name : Kirkland Section
Analysis Title: Basin A1 eco equiv.
Comments : Sizing eco embank using equivalent areas.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	4.160	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	4.160	0.000	
SUBBASIN TOTAL	4.160	4.160	0.000	

\
************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.046	0.808	
2-Year	0.085	1.060	0.041
5-Year	0.136	1.374	0.092
10-Year	0.174	1.609	0.138
25-Year	0.229	1.943	0.178
50-Year	0.276	2.220	0.202
100-Year	0.327	2.521	0.210
200-Year	0.385	2.851	0.316

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-12.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-6.0%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	2.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	6.5%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 18018. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 27028. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.041 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.75 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.43 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	**A2 Equivalent Area**

Effective Impervious Area (EIS) (acres)	1.39
Length of Pavement To WQ Treat (ft)	1226
MGS Online Flow (cfs)	0.25
MGS Offline Flow (cfs)	0.14

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to cfs 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	771.60	772
Offline Ecology Embankment Area Needed (sf)	432.10	432

If Length of ditch is assumed to be equal to pavement length enter length of pavement to be treated via sheet flow

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	0.63	4
Offline Ecology Ditch bottom width (ft)	0.35	4

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	193 LF

Ecology Ditch Design Req. (HRM pg 5-66)

slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

```
**********************************************************************************
**
                              MGS FLOOD
                            PROJECT REPORT

Program Version: 2.2.5                          Run Date: 06/30/2004 10:25 AM
**********************************************************************************
**

Input File Name: A2 eoc equiv.fld
Project Name   :  Kirkland Section
Analysis Title:  Basin A2 eco equiv
Comments       :  Sizing eco embank using equiv area.

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040    Puget East 40 in MAP      10/01/1939-10/01/2097
Evaporation Station   : 961040    Puget East 40 in MAP
Evaporation Scale Factor   : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name   : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins:  1


 ********** Subbasin Number: 1 **********
 ***Tributary to Node: 1
 ***Bypass to Node    : None
                ---------Area(Acres) -------------
                               ------Developed-----
                Predeveloped  To Node  Bypass Node  Include GW
Till Forest        1.390       0.000       0.000       No
Till Pasture       0.000       0.000       0.000       No
Till Grass         0.000       0.000       0.000       No
Outwash Forest     0.000       0.000       0.000       No
Outwash Pasture    0.000       0.000       0.000       No
Outwash Grass      0.000       0.000       0.000       No
Wetland            0.000       0.000       0.000       No
Impervious         0.000       1.390       0.000
SUBBASIN TOTAL     1.390       1.390       0.000
```

\
************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.016	0.270	
2-Year	0.029	0.354	0.014
5-Year	0.045	0.459	0.030
10-Year	0.058	0.538	0.047
25-Year	0.077	0.649	0.060
50-Year	0.092	0.742	0.068
100-Year	0.109	0.842	0.070
200-Year	0.129	0.953	0.080

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-16.8%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-7.3%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	3.7%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	11.2%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
******************* Water Quality Facility Data **************

Basic Wet Pond Volume (91% Exceedance): 6021. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 9031. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.014 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.25 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.14 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	B4.1 Equivalent Area

Effective Impervious Area (EIS) (acres)	1.28
Length of Pavement To WQ Treat (ft)	485
MGS Online Flow (cfs)	0.23
MGS Offline Flow (cfs)	0.13

<u>Ecology Embankment Size</u>

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to cfs 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	709.88	710
Offline Ecology Embankment Area Needed (sf)	401.23	401

If Length of ditch is assumed to be equal to pavement length enter length of pavement to be treated via sheet flow

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	1.46	4
Offline Ecology Ditch bottom width (ft)	0.83	4

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	177.5 LF

<u>Ecology Ditch Design Req. (HRM pg 5-66)</u>

slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

****
**

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 08/19/2004 3:26 PM
****
**

Input File Name: B4.1 eco equiv.fld
Project Name : Kirkland Section
Analysis Title: Basin B4.1 eco equiv
Comments : Sizing of ecology embank using equiv. area

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.280	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.280	0.000	
SUBBASIN TOTAL	1.280	1.280	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

\
************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	0.014	0.249
2-Year	0.026	0.326
5-Year	0.042	0.423
10-Year	0.053	0.495
25-Year	0.070	0.598
50-Year	0.085	0.683
100-Year	0.101	0.776
200-Year	0.118	0.877

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

\
******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 5544. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 8316. cu-ft

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.23 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.13 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	**B4.2 Equivalent Area**

Effective Impervious Area (EIS) (acres)	1.74
Length of Pavement To WQ Treat (ft)	1250
MGS Online Flow (cfs)	0.31
MGS Offline Flow (cfs)	0.18

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to cfs 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	956.79	957
Offline Ecology Embankment Area Needed (sf)	555.56	556

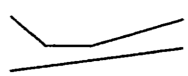
If Length of ditch is assumed to be equal to pavement length enter length of pavement to be treated via sheet flow

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	0.77	4
Offline Ecology Ditch bottom width (ft)	0.44	4

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	239.25 LF

Ecology Ditch Design Req. (HRM pg 5-66)



slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/30/2004 2:59 PM
****

Input File Name: Basin B4.2 eco equiv.fld
Project Name : Kirkland Section
Analysis Title: Basin B4.2 eco equiv
Comments : Sizing of eco embank using equiv. areas

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.740	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.740	0.000	
SUBBASIN TOTAL	1.740	1.740	0.000	

\
************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.019	0.338	
2-Year	0.036	0.443	0.017
5-Year	0.057	0.575	0.038
10-Year	0.073	0.673	0.058
25-Year	0.096	0.813	0.075
50-Year	0.115	0.928	0.085
100-Year	0.137	1.054	0.088
200-Year	0.161	1.192	0.101

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-15.1%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-6.3%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	3.7%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	9.3%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
******************* Water Quality Facility Data **************

Basic Wet Pond Volume (91% Exceedance): 7537. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 11305. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.017 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.31 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.18 cfs

****

HNTB The HNTB Companies	Made by	Date	Job Number
	Checked by	Date	Sheet Number
Calculations For	Backchecked by	Date	

BASIN C NICKEL NEW PAVEMENT AREA = 9.61 AC

BASIN C AREA REQ. TO BE TREATED = 9.61 AC

BASIN C SUB-CATCHMENT AREAS

	AREA OF SHEET FLOW TO ECO. EMBANK. FOR TREATMENT	AREA OF ECO. EMBANK REQ. TO TREAT AREA OF SHEET FLOW	AREA PROVIDED BY ECO. EMBANK W/ 4' MIN. WIDTH	% OF TREAT PROVIDED
C.1	2.20 AC	1,235 SF	4,545 SF	368 %
C.2	1.71 AC	957 SF	3,574 SF	373 %
C.3	1.46 AC	802 SF	2,975 SF	371 %
C.4	2.86 AC	1605 SF	5,350 SF	333 %
C.5	4.24 AC	2,377 SF	10,336 SF	435 %
TOTALS	12.47 AC	6,976 SF	26,780 SF	384 %

12.47 AC > 9.61 AC REQ. TO BE TREATED SO OK ✓

EMBANKMENTS WITH A WIDTH OF 4' ARE TREATING 384 % OF THE AREA REQ. TO BE TREATED. ✓

SEE WQ AREA DWGS FOR AREA REFERENCE

ME111-0793

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	**C.1 equiv.**
Effective Impervious Area (EIS) (acres)	2.20
Length of Pavement To WQ Treat (ft)	1133
MGS Online Flow (cfs)	0.40
MGS Offline Flow (cfs)	0.23

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to cfs 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	1,234.57	1,235
Offline Ecology Embankment Area Needed (sf)	709.88	710

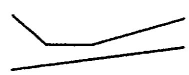
If Length of ditch is assumed to be equal to pavement length enter length of pavement to be treated via sheet flow

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	1.09	4
Offline Ecology Ditch bottom width (ft)	0.63	4

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	308.75 LF

Ecology Ditch Design Req. (HRM pg 5-66)



slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5   Run Date: 07/01/2004 8:53 AM

****

Input File Name: C.1 eco equiv.fld
Project Name : Kirkland Section
Analysis Title: Basin C.1 eco equiv
Comments   : Sizing ecology embank using equiv. area

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040   Puget East 40 in MAP   10/01/1939-10/01/2097
Evaporation Station   : 961040   Puget East 40 in MAP
Evaporation Scale Factor   : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node   : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	2.200	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	2.200	0.000	
SUBBASIN TOTAL	2.200	2.200	0.000	

\
************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.025	0.427	
2-Year	0.045	0.560	0.021
5-Year	0.072	0.726	0.048
10-Year	0.092	0.851	0.074
25-Year	0.121	1.028	0.095
50-Year	0.146	1.174	0.107
100-Year	0.173	1.333	0.111
200-Year	0.203	1.508	0.121

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-15.7%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-7.2%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	2.4%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	7.5%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 9529. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 14293. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.021 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.40 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.23 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	C.2 equiv.

Effective Impervious Area (EIS) (acres)	1.71
Length of Pavement To WQ Treat (ft)	866
MGS Online Flow (cfs)	0.31
MGS Offline Flow (cfs)	0.18

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to cfs 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	956.79	957
Offline Ecology Embankment Area Needed (sf)	555.56	556

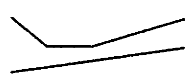
If Length of ditch is assumed to be equal to pavement length enter length of pavement to be treated via sheet flow

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	1.10	4
Offline Ecology Ditch bottom width (ft)	0.64	4

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	239.25 LF

Ecology Ditch Design Req. (HRM pg 5-66)



slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 07/01/2004 9:11 AM

****

Input File Name: C.2 eco equiv.fld
Project Name : Kirkland Section
Analysis Title: Basin C.2 eco equiv.
Comments : Sizing of ecology embank using equiv. area

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.710	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.710	0.000	
SUBBASIN TOTAL	1.710	1.710	0.000	

\
************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.019	0.332	
2-Year	0.035	0.436	0.017
5-Year	0.056	0.565	0.038
10-Year	0.071	0.662	0.057
25-Year	0.094	0.799	0.074
50-Year	0.113	0.912	0.084
100-Year	0.135	1.036	0.087
200-Year	0.158	1.172	0.100

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-15.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-6.2%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	3.7%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	9.3%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

\
****************** Water Quality Facility Data **************

Basic Wet Pond Volume (91% Exceedance): 7407. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 11110. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.017 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.31 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.18 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	**C.3 equiv.**

Effective Impervious Area (EIS) (acres)	1.46
Length of Pavement To WQ Treat (ft)	735
MGS Online Flow (cfs)	0.26
MGS Offline Flow (cfs)	0.15

<u>Ecology Embankment Size</u>

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to cfs 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	802.47	802
Offline Ecology Embankment Area Needed (sf)	462.96	463

If Length of ditch is assumed to be equal to pavement length enter length of pavement to be treated via sheet flow

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	1.09	4
Offline Ecology Ditch bottom width (ft)	0.63	4

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	200.5 LF

<u>Ecology Ditch Design Req. (HRM pg 5-66)</u>

slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

S:\000\drainage\Kirkland\New Pave 06.25.04\Ecology ditch sizing C.3 equiv (06.29.04)
7/1/20049:25 AM

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**

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 07/01/2004 9:59 AM
****
**

Input File Name: C.3 eco equiv.fld
Project Name : Kirkland Section
Analysis Title: Basin C.3 eco equiv
Comments : Sizing of ecology embank using equiv. area

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.460	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.460	0.000	
SUBBASIN TOTAL	1.460	1.460	0.000	

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************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.016	0.284	
2-Year	0.030	0.372	0.014
5-Year	0.048	0.482	0.032
10-Year	0.061	0.565	0.049
25-Year	0.080	0.682	0.063
50-Year	0.097	0.779	0.072
100-Year	0.115	0.885	0.074
200-Year	0.135	1.001	0.083

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-16.9%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-7.5%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	3.7%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	9.3%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

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****************** Water Quality Facility Data **************

Basic Wet Pond Volume (91% Exceedance): 6324. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 9486. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.014 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.26 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.15 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	C.4 equiv.
Effective Impervious Area (EIS) (acres)	2.86
Length of Pavement To WQ Treat (ft)	1450
MGS Online Flow (cfs)	0.52
MGS Offline Flow (cfs)	0.29

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to cfs 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	1,604.94	1,605
Offline Ecology Embankment Area Needed (sf)	895.06	895

If Length of ditch is assumed to be equal to pavement length enter length of pavement to be treated via sheet flow

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	1.11	4
Offline Ecology Ditch bottom width (ft)	0.62	4

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	401.25 LF

Ecology Ditch Design Req. (HRM pg 5-66)

slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

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********************************************************************************
**
                              MGS FLOOD
                            PROJECT REPORT

Program Version: 2.2.5                        Run Date: 07/01/2004 9:34 AM
********************************************************************************
**

Input File Name: C.4 eco equiv..fld
Project Name   : Kirkland Section
Analysis Title: Basin C.4 eco equiv
Comments       : Sizing of eco embank using equiv. areas

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040   Puget East 40 in MAP    10/01/1939-10/01/2097
Evaporation Station   : 961040   Puget East 40 in MAP
Evaporation Scale Factor   : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name  : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
\
********** Watershed Definition **********
Number of Subbasins:  1


 ********** Subbasin Number: 1 **********
 ***Tributary to Node: 1
 ***Bypass to Node   : None
                  ---------Area(Acres) -------------
                                ------Developed-----
                  Predeveloped  To Node  Bypass Node  Include GW
Till Forest          2.860       0.000       0.000       No
Till Pasture         0.000       0.000       0.000       No
Till Grass           0.000       0.000       0.000       No
Outwash Forest       0.000       0.000       0.000       No
Outwash Pasture      0.000       0.000       0.000       No
Outwash Grass        0.000       0.000       0.000       No
Wetland              0.000       0.000       0.000       No
Impervious           0.000       2.860       0.000
SUBBASIN TOTAL       2.860       2.860       0.000
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************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.032	0.556	
2-Year	0.059	0.728	0.028
5-Year	0.093	0.944	0.064
10-Year	0.120	1.106	0.095
25-Year	0.158	1.336	0.123
50-Year	0.190	1.526	0.138
100-Year	0.225	1.733	0.143
200-Year	0.264	1.960	0.233

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-11.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-4.9%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	2.8%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	7.4%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

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******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 12388. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 18582. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.028 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.52 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.29 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	C.5 equiv.
Effective Impervious Area (EIS) (acres)	4.24
Length of Pavement To WQ Treat (ft)	2960
MGS Online Flow (cfs)	0.77
MGS Offline Flow (cfs)	0.44

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to cfs 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	2,376.54	2,377
Offline Ecology Embankment Area Needed (sf)	1,358.02	1,358

If Length of ditch is assumed to be equal to pavement length enter length of pavement to be treated via sheet flow

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	0.80	4
Offline Ecology Ditch bottom width (ft)	0.46	4

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	594.25 LF

<u>Ecology Ditch Design Req. (HRM pg 5-66)</u>

slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 07/01/2004 9:42 AM
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**

Input File Name: C.5 eco equiv.fld
Project Name : Kirkland Section
Analysis Title: Basin C.5 eco equiv
Comments : Sizing of eco embank using equiv. area

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
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********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	4.240	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	4.240	0.000	
SUBBASIN TOTAL	4.240	4.240	0.000	

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************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.047	0.824	
2-Year	0.087	1.080	0.042
5-Year	0.138	1.400	0.094
10-Year	0.177	1.640	0.141
25-Year	0.234	1.980	0.182
50-Year	0.281	2.262	0.206
100-Year	0.334	2.570	0.214
200-Year	0.392	2.906	0.321

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

\
**** Flow Duration Performance According to Dept. of Ecology Criteria ****

Excursion at Predeveloped ½Q2 (Must be Less Than 0%):	-12.0%	PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%):	-6.1%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	2.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	6.5%	PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

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******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 18365. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 27547. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.042 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.77 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.44 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	**TDA-D1**
Effective Impervious Area (EIS) (acres)	0.81
Length of Pavement To WQ Treat (ft)	
MGS Online Flow (cfs)	0.15
MGS Offline Flow (cfs)	0.08

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (leco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

leco= infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

leco converted to fps 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	462.96	463
Offline Ecology Embankment Area Needed (sf)	246.91	247

If Length of Ecology Embankment is equal to pavement length, enter length of pavement to be treated via sheet flow above:

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!
Offline Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ **5-ft**

Minimum Length Required for Ecology Embankment	92.6 LF

Ecology Ditch Design Req. (HRM pg 5-66)

slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 08/17/2004 3:32 PM
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**

Input File Name: D1 eco.fld
Project Name : Kirkland Section
Analysis Title: Basin D1 ecology embankment
Comments : Sizing of ecology embankment

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************
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********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------	------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.810	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	0.810	0.000	
SUBBASIN TOTAL	0.810	0.810	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

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************** Flow Frequency Data for Selected Recurrence Intervals
****

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	0.009	0.157
2-Year	0.017	0.206
5-Year	0.026	0.267
10-Year	0.034	0.313
25-Year	0.045	0.378
50-Year	0.054	0.432
100-Year	0.064	0.491
200-Year	0.075	0.555

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

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****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 3508. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 5263. cu-ft

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.15 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.08 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	TDA-D3

Effective Impervious Area (EIS) (acres)	3.50
Length of Pavement To WQ Treat (ft)	
MGS Online Flow (cfs)	0.63
MGS Offline Flow (cfs)	0.36

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76
* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)
Qmgsflood = Flow rate from water quality output of MGSFlood
Ieco= infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)
Aeco= area of ecology ditch
Ieco converted to fps 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	1944.44	1,944
Offline Ecology Embankment Area Needed (sf)	1111.11	1,111

If Length of Ecology Embankment is equal to pavement length, enter length of pavement to be treated via sheet flow above:

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!
Offline Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	486 LF

<u>Ecology Ditch Design Req. (HRM pg 5-66)</u>

slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/28/2004 1:57 PM
****

Input File Name: D3.fld
Project Name : Kirkland Section
Analysis Title: Basin D3 all pave - Eco Embankment
Comments : Ecology Embankment sizing calculation

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	3.500	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	3.500	0.000	
SUBBASIN TOTAL	3.500	3.500	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	0.039	0.680
2-Year	0.072	0.891
5-Year	0.114	1.156
10-Year	0.146	1.354
25-Year	0.193	1.635
50-Year	0.232	1.867
100-Year	0.275	2.121
200-Year	0.324	2.399

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 15160. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 22740. cu-ft

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.63 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.36 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	**TDA-D4.1**

Effective Impervious Area (EIS) (acres)	1.27
Length of Pavement To WQ Treat (ft)	
MGS Online Flow (cfs)	0.23
MGS Offline Flow (cfs)	0.13

<u>Ecology Embankment Size</u>

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to fps 0.000324

	Calculated Area	**Design Area**
Online Ecology Embankment Area Needed (sf)	709.88	710
Offline Ecology Embankment Area Needed (sf)	401.23	401

If Length of Ecology Embankment is equal to pavement length, enter length of pavement to be treated via sheet flow above:

	Calculated Width	**Design Width**
Online Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!
Offline Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	177.5 LF

<u>Ecology Ditch Design Req. (HRM pg 5-66)</u>

slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

S:\000\drainage\Kirkland\New Pave 06.25.04\Ecology ditch sizing D4.1 (06.28.04)
6/28/20043:02 PM

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/28/2004 2:59 PM
****

Input File Name: D4.1 Eco.fld
Project Name : Kirkland Section
Analysis Title: Basin D4.1 all pave - Eco Embankment
Comments : Ecology Embankment sizing calcs

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.270	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.270	0.000	
SUBBASIN TOTAL	1.270	1.270	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	0.014	0.247
2-Year	0.026	0.323
5-Year	0.041	0.419
10-Year	0.053	0.491
25-Year	0.070	0.593
50-Year	0.084	0.678
100-Year	0.100	0.770
200-Year	0.117	0.870

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 5501. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 8251. cu-ft

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.23 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.13 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	**TDA-D4.2**
Effective Impervious Area (EIS) (acres)	1.85
Length of Pavement To WQ Treat (ft)	
MGS Online Flow (cfs)	0.33
MGS Offline Flow (cfs)	0.19

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to fps 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	1,018.52	1,019
Offline Ecology Embankment Area Needed (sf)	586.42	586

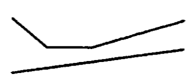
If Length of Ecology Embankment is equal to pavement length, enter length of pavement to be treated via sheet flow above:

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!
Offline Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	254.75 LF

Ecology Ditch Design Req. (HRM pg 5-66)



slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/28/2004 3:05 PM
****

Input File Name: D4.2 Eco.fld
Project Name : Kirkland Section
Analysis Title: Basin D4.2 all pave - Eco Embankment
Comments : Ecology Embankment sizing calcs

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

---------Area(Acres) -------------				
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.850	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.850	0.000	
SUBBASIN TOTAL	1.850	1.850	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	0.021	0.359
2-Year	0.038	0.471
5-Year	0.060	0.611
10-Year	0.077	0.716
25-Year	0.102	0.864
50-Year	0.123	0.987
100-Year	0.146	1.121
200-Year	0.171	1.268

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 8013. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 12020. cu-ft

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.33 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.19 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	TDA-E1

Effective Impervious Area (EIS) (acres)	2.99
Length of Pavement To WQ Treat (ft)	
MGS Online Flow (cfs)	0.54
MGS Offline Flow (cfs)	0.31

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)
Qmgsflood = Flow rate from water quality output of MGSFlood
Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)
Aeco= area of ecology ditch
Ieco converted to fps 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	1,666.67	1,667
Offline Ecology Embankment Area Needed (sf)	956.79	957

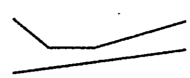
If Length of Ecology Embankment is equal to pavement length, enter length of pavement to be treated via sheet flow above:

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!
Offline Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	416.75 LF

Ecology Ditch Design Req. (HRM pg 5-66)



slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

S:\000\drainage\Kirkland\New Pave 06.25.04\Ecology ditch sizing E1 (06.28.04)
6/28/20042:43 PM

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MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/28/2004 2:43 PM
****

Input File Name: E1 Eco.fld
Project Name : Kirkland Section
Analysis Title: Basin E1 all pave - Eco Embankment
Comments : Ecology Embankment sizing calculations

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	2.990	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	2.990	0.000	
SUBBASIN TOTAL	2.990	2.990	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	0.033	0.581
2-Year	0.061	0.762
5-Year	0.097	0.987
10-Year	0.125	1.157
25-Year	0.165	1.397
50-Year	0.198	1.595
100-Year	0.235	1.812
200-Year	0.276	2.049

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 12951. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 19426. cu-ft

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.54 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.31 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	TDA-E2
Effective Impervious Area (EIS) (acres)	4.02
Length of Pavement To WQ Treat (ft)	
MGS Online Flow (cfs)	0.73
MGS Offline Flow (cfs)	0.41

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to fps 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	2,253.09	2,253
Offline Ecology Embankment Area Needed (sf)	1,265.19	1,265

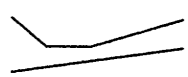
If Length of Ecology Embankment is equal to pavement length, enter length of pavement to be treated via sheet flow above:

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!
Offline Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment 563.25 LF

Ecology Ditch Design Req. (HRM pg 5-66)



slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/28/2004 3:16 PM
****

Input File Name: E2 Eco.fld
Project Name : Kirkland Section
Analysis Title: Basin E2 all pave - Eco Embankment
Comments : Ecology Embankment sizing calcs

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	4.020	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	4.020	0.000	
SUBBASIN TOTAL	4.020	4.020	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	0.045	0.781
2-Year	0.083	1.024
5-Year	0.131	1.327
10-Year	0.168	1.555
25-Year	0.221	1.878
50-Year	0.266	2.145
100-Year	0.316	2.436
200-Year	0.372	2.755

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 17412. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 26118. cu-ft

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.73 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.41 cfs

****

Ecology Embankment Design Calcs.

Calculation formulas revised 6/25/04

Basin Name	TDA-F1

Effective Impervious Area (EIS) (acres)	1.48
Length of Pavement To WQ Treat (ft)	
MGS Online Flow (cfs)	0.27
MGS Offline Flow (cfs)	0.15

Ecology Embankment Size

* WSDOT HRM March 2004 pg 5-69 to 5-76

* Min. ditch bottom width of 4'

Qmgsflood < (Ieco)*(Aeco)

Qmgsflood = Flow rate from water quality output of MGSFlood

Ieco= Infiltration rate through ecology mix (14 in/hr pg. 5-75 WSDOT HRM)

Aeco= area of ecology ditch

Ieco converted to fps 0.000324

	Calculated Area	Design Area
Online Ecology Embankment Area Needed (sf)	833.33	833
Offline Ecology Embankment Area Needed (sf)	462.96	463

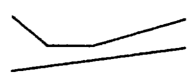
If Length of Ecology Embankment is equal to pavement length, enter length of pavement to be treated via sheet flow above:

	Calculated Width	Design Width
Online Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!
Offline Ecology Ditch bottom width (ft)	#DIV/0!	#DIV/0!

If Ecology Embankment length is not equal to the length of associated adjacent pavement:
Assume Minimum Ecology Embankment width @ 4-ft

Minimum Length Required for Ecology Embankment	208.25 LF

Ecology Ditch Design Req. (HRM pg 5-66)



slope < 21% lateral gradient 3:1 min.
slope < 4% longitudinal gradient (length of ditch)
avoid wetlands
avoid areas with high water tables
avoid seismic hazard areas
avoid unstable slopes
NVZ = 1' - 3' wide min. 18" deep
Veg. filter strip = min. 3' width
media bed use 14 in/hr infiltration rate
underdrain min. 2' wide 8" PVC perforated pipe 30-45 degrees from vertical
width of bottom of ditch min. 4'
ecology mix min. 12" deep including part on top of underdrain pipe
ditch must pass 100 year storm with 6" freeboard using biofiltration swale analysis

****
MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/28/2004 4:28 PM
****

Input File Name: F1 Eco.fld
Project Name : Kirkland Section
Analysis Title: Basin F1 all pave - Eco Embankment
Comments : Ecology Embankment sizing calcs

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	1.480	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	1.480	0.000	
SUBBASIN TOTAL	1.480	1.480	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	0.017	0.288
2-Year	0.030	0.377
5-Year	0.048	0.489
10-Year	0.062	0.573
25-Year	0.082	0.691
50-Year	0.098	0.790
100-Year	0.116	0.897
200-Year	0.137	1.014

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 6410. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 9616. cu-ft

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.27 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.15 cfs

****

Combined Wetland / Detention Pond Sizing for TDA-F3 / TDA-F4

Surface Area of Wetland Cell = Top Area of Wet Pond

3422-cf / 3-ft depth = 1141-sf

Size Presettling in Retention/Detention Pond:

For sizing: assume forbay = 25% wet pool volume

3422-cf x (0.25) / 4-ft depth = 214-sf

Volume => 3422-cf (0.25) = 856-cf

Size Second Cell of Retention/Detention Pond:

Total Required Detention Volume (Max Stage) = 21,752-cf

Volume required for second cell => 21752-cf - 856-cf = 20,896-cf

Area of second cell: assume depth of 5-ft; Surface area = approx. 4,180-sf

Surface Area of Wetland Cell:

1141-sf - 214-sf = 927-sf

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 06/15/2004 8:12 AM
****

Input File Name: F3.fld
Project Name : Kirkland Section
Analysis Title: Basin F3 – Detention Sizing for Combined Detention/Wetland Facility
Comments : Using 100% forested predeveloped condition

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	Area(Acres) Predeveloped	Developed To Node	Developed Bypass Node	Include GW
Till Forest	0.790	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	0.000	0.790	0.000	
SUBBASIN TOTAL	0.790	0.790	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 -------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used

---------------- Pond Geometry ----------------

Prismatic Pond Option Used

Pond Floor Elevation : 100.00 ft
Riser Crest Elevation : 104.50 ft
Maximum Pond Elevation : 105.00 ft
Maximum Storage Depth : 4.50 ft
Pond Bottom Length : 70.4 ft
Pond Bottom Width : 35.2 ft
Side Slope : 3.00 ft/ft
Infiltration Rate : 0.00 in/hr
Pond Bottom Area : 2478. sq-ft
Area at Riser Crest El : 6058. sq-ft
: 0.139 acres
Volume at Riser Crest : 18616. cu-ft
: 0.427 ac-ft
Area at Max Elevation : 6546. sq-ft
: 0.150 acres
Volume at Max Elevation: 21752. cu-ft
: 0.499 ac-ft

---------------- Riser Geometry ----------------
Riser Structure Type : Circular
Riser Diameter : 18.00 in
Common Length : 0.008 ft
Riser Crest Elevation : 104.50 ft

--------- Hydraulic Structure Geometry ----------

Number of Devices: 3

--- Device Number 1 ---
Device Type : Circular Orifice
Invert Elevation : 100.50 ft
Diameter : 0.43 in

Orientation : Horizontal
Elbow : No

--- Device Number 2 ---
Device Type : Vertical Rectangular Orifice
Invert Elevation : 103.21 ft
Length : 0.1 in
Height : 15.5 in
Orientation : Vertical
Elbow : No

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	8.810E-03	0.153	
2-Year	0.016	0.201	7.832E-03
5-Year	0.026	0.261	0.017
10-Year	0.033	0.306	0.026
25-Year	0.044	0.369	0.033
50-Year	0.052	0.422	0.037
100-Year	0.062	0.479	0.037
200-Year	0.073	0.541	0.064

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

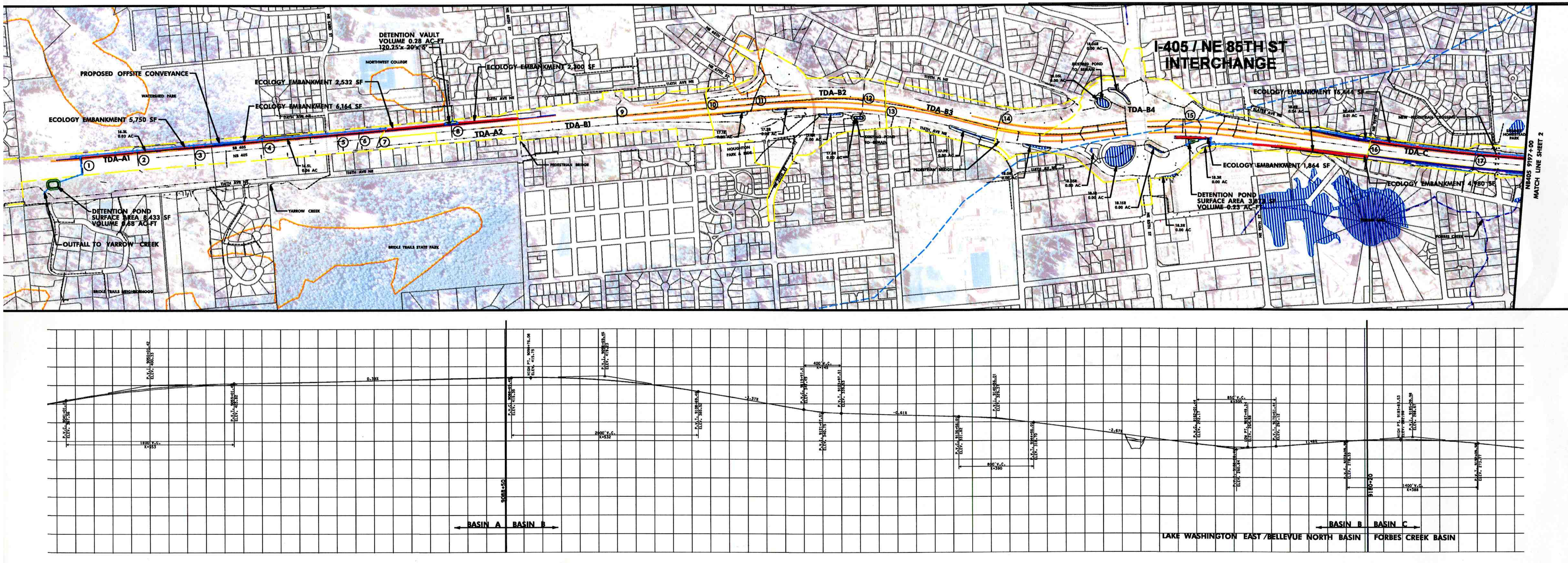
**** Flow Duration Performance According to Dept. of Ecology Criteria ****
Excursion at Predeveloped ½Q2 (Must be Less Than 0%): -13.6% PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%): -4.6% PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): -1.7% PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 0.0% PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

****************** Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 3422. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 5133. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.008 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs



DRAINAGE FEATURES

- DETENTION FACILITY
- WATER QUALITY FACILITY
- PROPOSED CONVEYANCE
- EXISTING CONVEYANCE

KING COUNTY GIS INFO

- SHORE LINE
- WATER BODIES
- STREAM/DITCH LINE
- SEISMIC
- STREAM BOUNDARY
- LANDSLIDE HAZARD
- EROSION HAZARD
- WETLAND

CROSS CULVERT I.D.

- NEW PAVEMENT
- REPLACED PAVEMENT
- REMOVED PAVEMENT

0 200 400
SCALE IN FEET

INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS

NICKEL DRAINAGE PLAN

NB 405 9039+00 TO NB 405 9197+00

SHEET 1 OF 3 SHEETS

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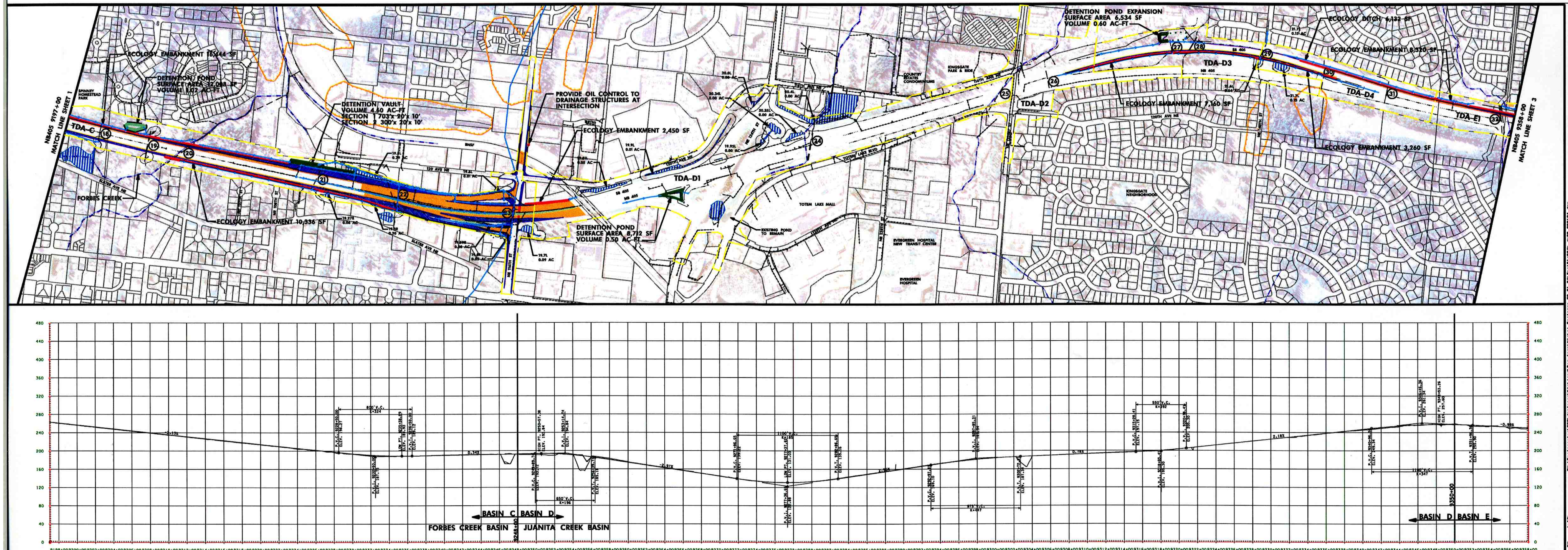


DRAINAGE FEATURES
- DETENTION FACILITY
- WATER QUALITY FACILITY
- PROPOSED CONVEYANCE
- EXISTING CONVEYANCE

KING COUNTY GIS INFO
- SHORE LINE
- WATER BODIES
- STREAM/DITCH LINE
- SEISMIC
- STREAM BOUNDARY
- LANDSLIDE HAZARD
- EROSION HAZARD
- WETLAND

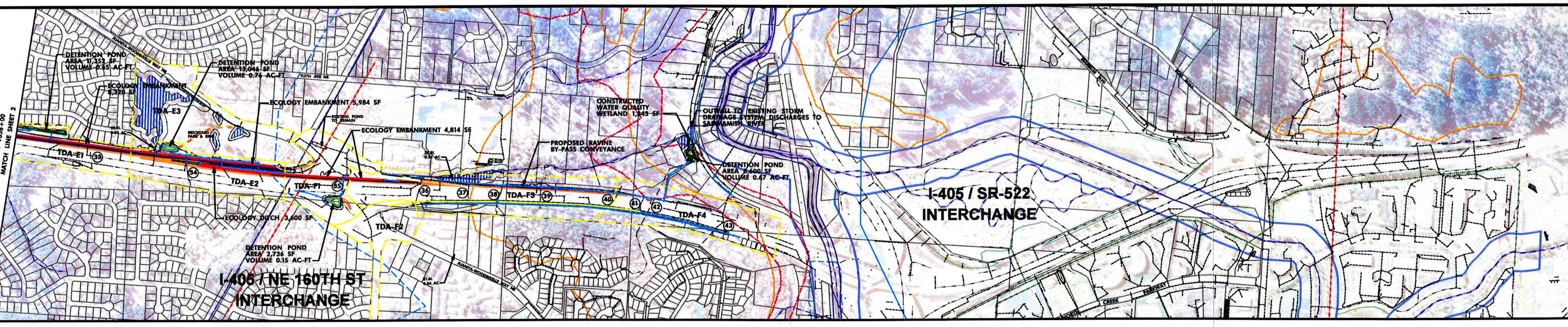
(#) CROSS CULVERT I.D.
- NEW PAVEMENT
- REPLACED PAVEMENT
- REMOVED PAVEMENT

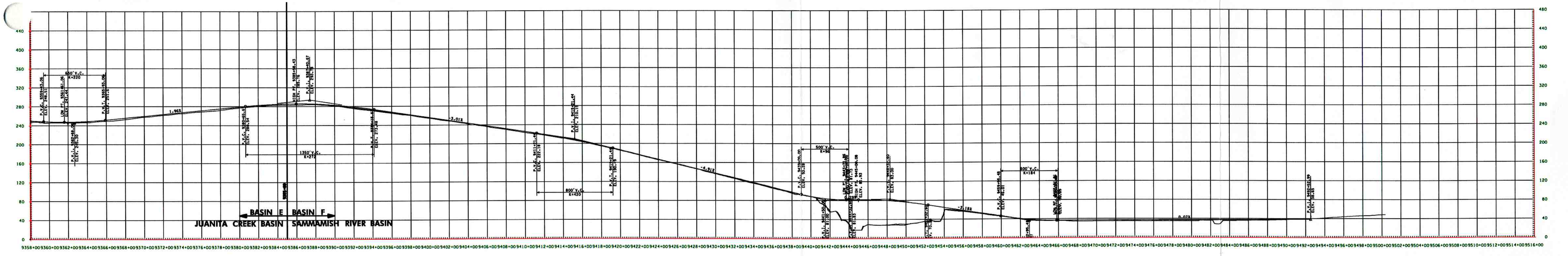
0 200 400
SCALE IN FEET

INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
NICKEL DRAINAGE PLAN
NB405 9197+00 TO NB405 9358+00

SHEET 2 OF 3 SHEETS





DRAINAGE FEATURES

- DETENTION FACILITY
- WATER QUALITY FACILITY
- PROPOSED CONVEYANCE
- EXISTING CONVEYANCE

KING COUNTY GIS INFO

- SHORE LINE
- WATER BODIES
- STREAM/DITCH LINE
- SEISMIC
- STREAM BOUNDARY
- LANDSLIDE HAZARD
- EROSION HAZARD
- WETLAND

\# CROSS CULVERT I.D.

- NEW PAVEMENT
- REPLACED PAVEMENT
- REMOVED PAVEMENT

0 200 400
SCALE IN FEET

INTERSTATE 405 Project Team
Washington State Department of Transportation

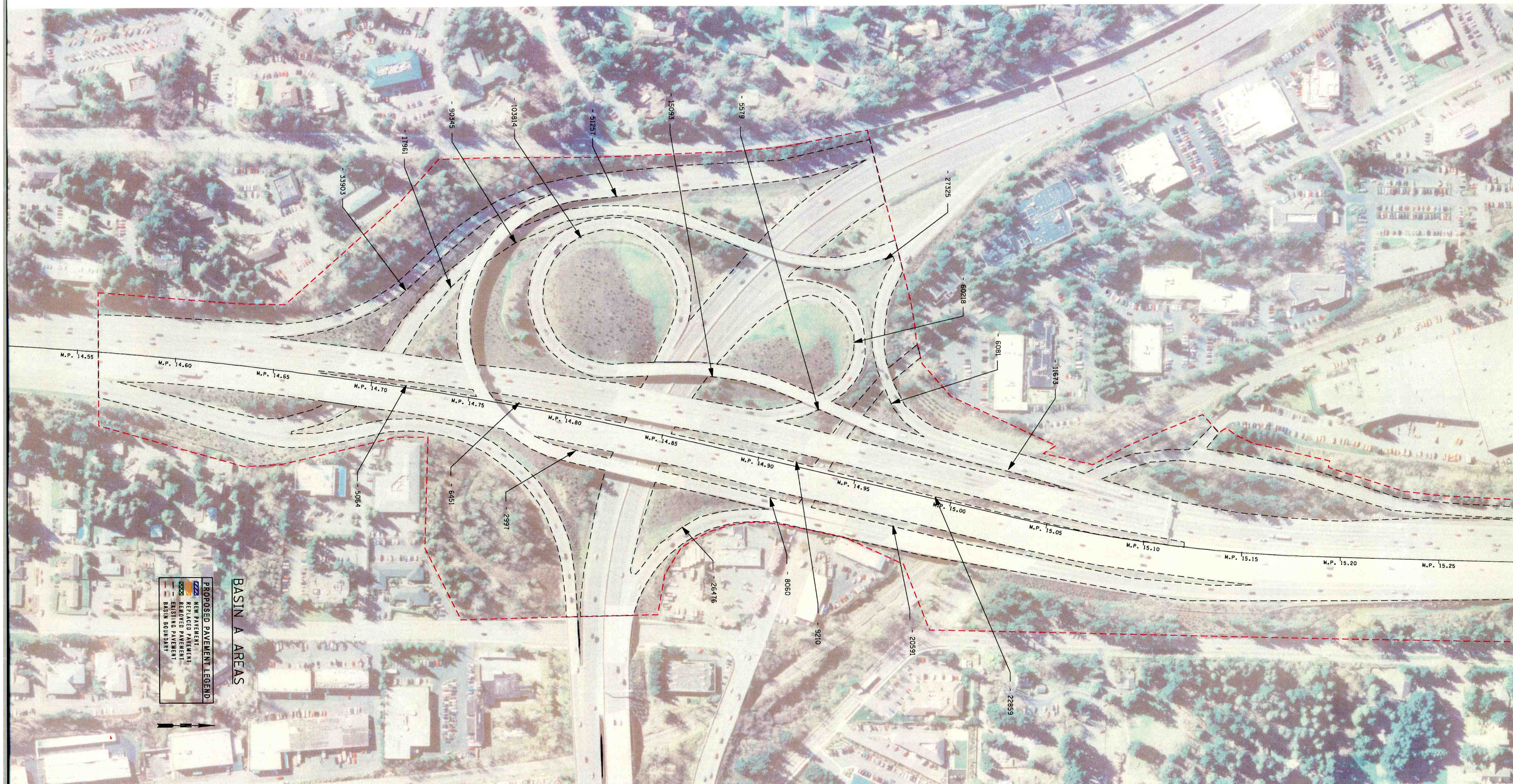
I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
NICKEL
DRAINAGE PLAN

NB405 9358+00 TO NB405 9514+08.43

SHEET 3 OF 3 SHEETS

11/3/2004

STORM WATER DETENTION AREA DRAWINGS


BASIN A AREAS
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
M.P. 14.55
M.P. 14.60
M.P. 14.65
M.P. 14.70
M.P. 14.75
M.P. 14.80
M.P. 14.85
M.P. 14.90
M.P. 14.95
M.P. 15.00
M.P. 15.05
M.P. 15.10
M.P. 15.15
M.P. 15.20
M.P. 15.25
33903
17961
90345
103814
51257
15093
5579
27325
60218
6081
11673
5064
6451
2997
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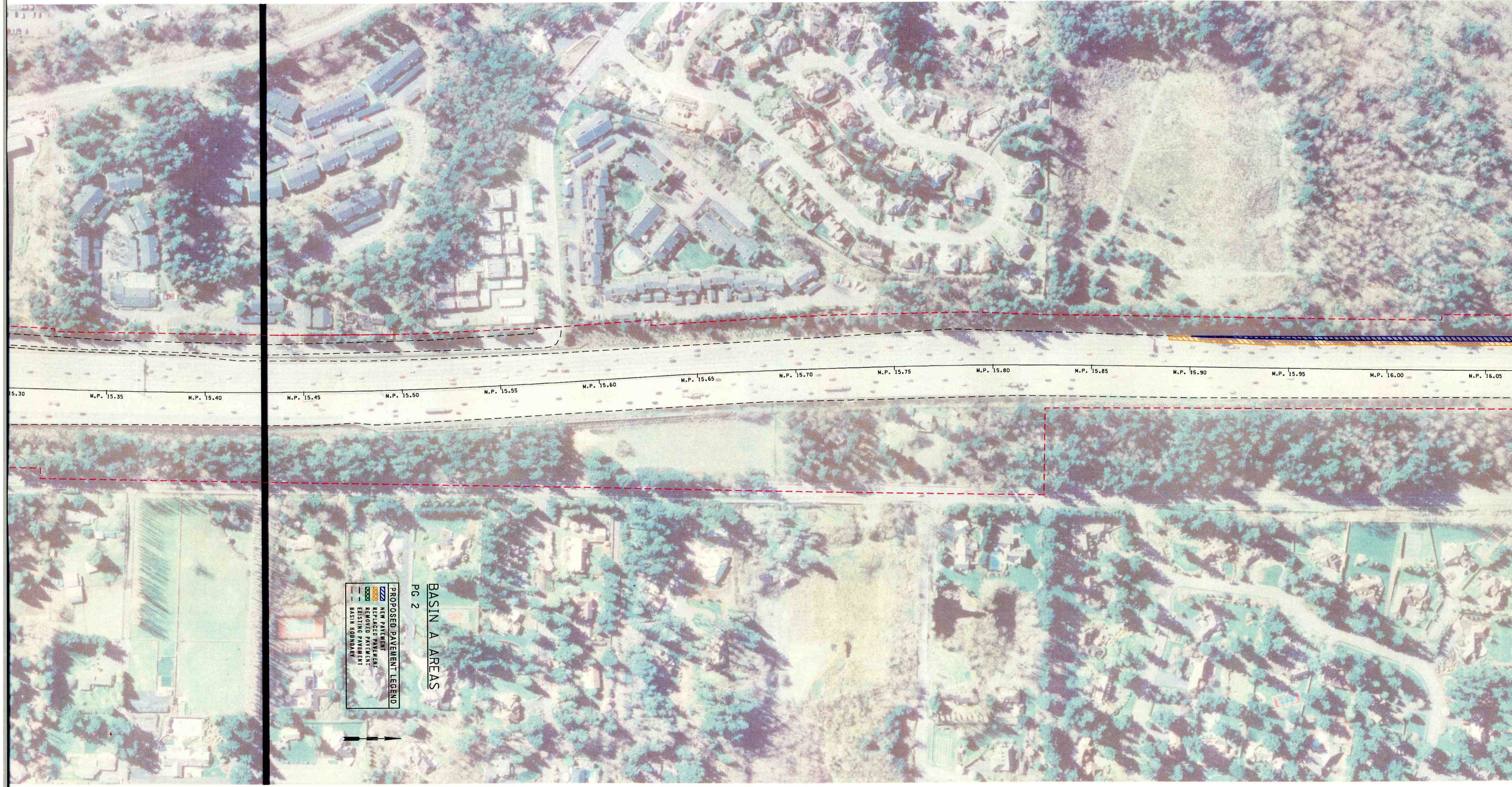
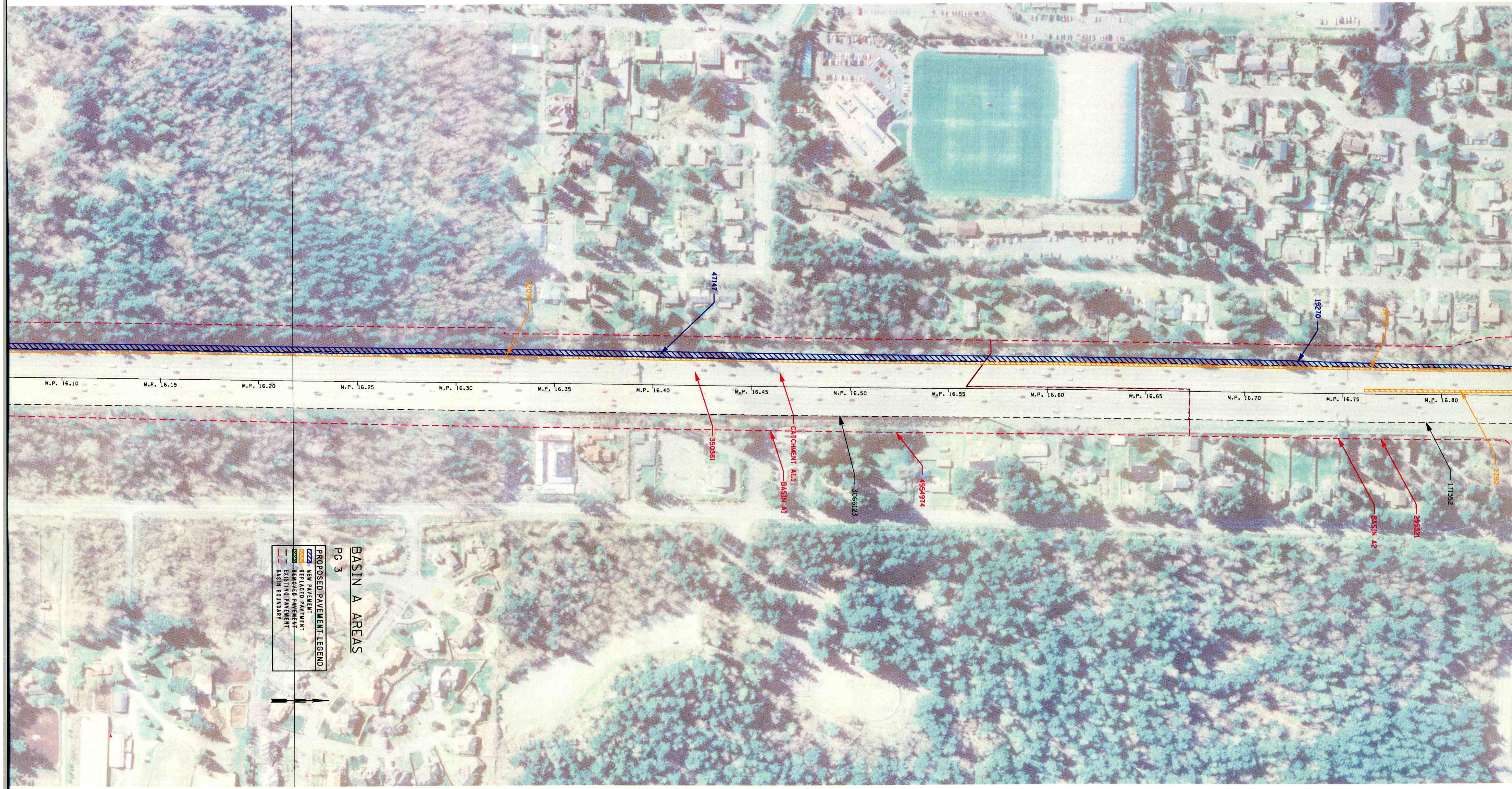
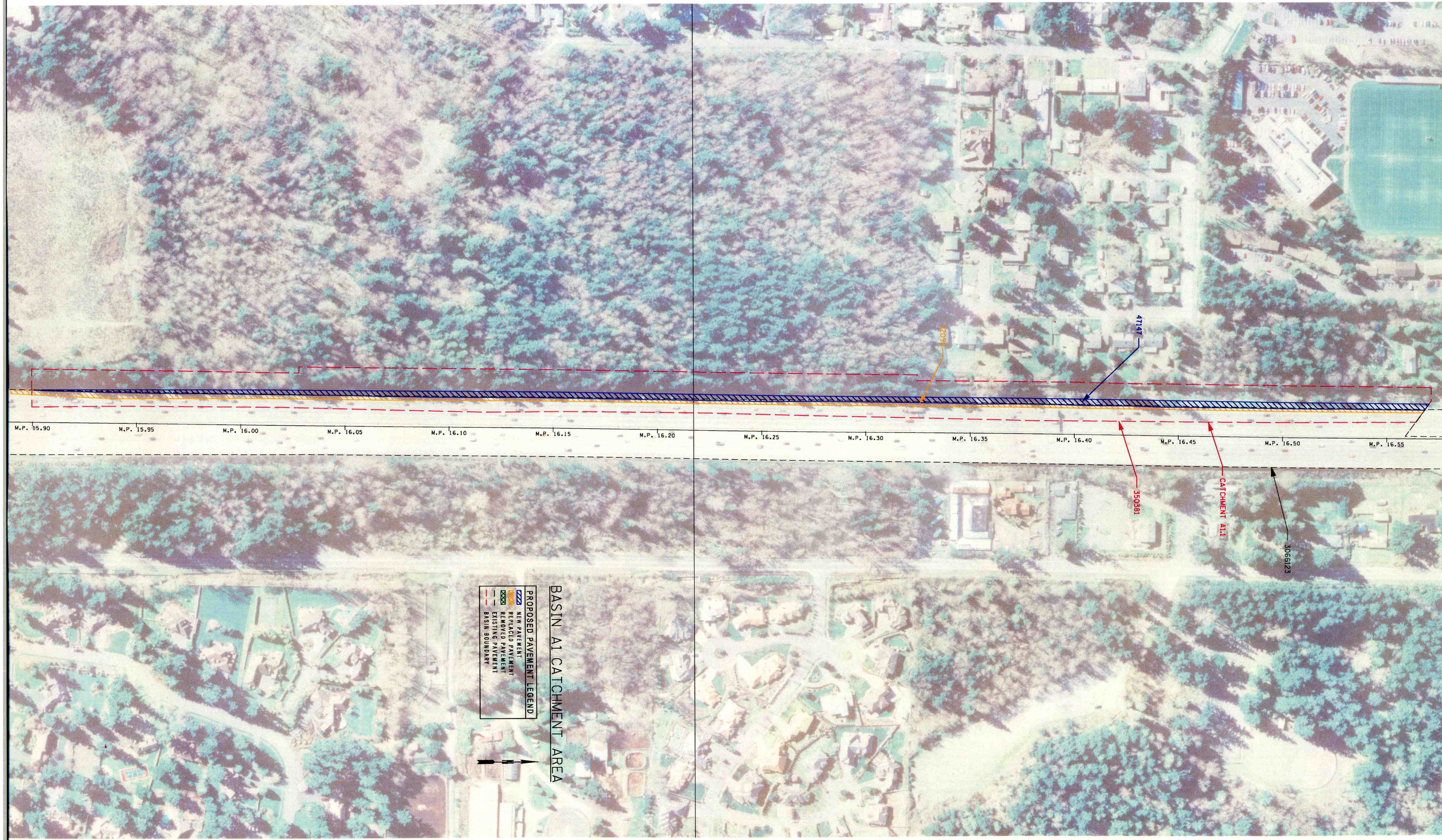
8060
9210
20591
22859

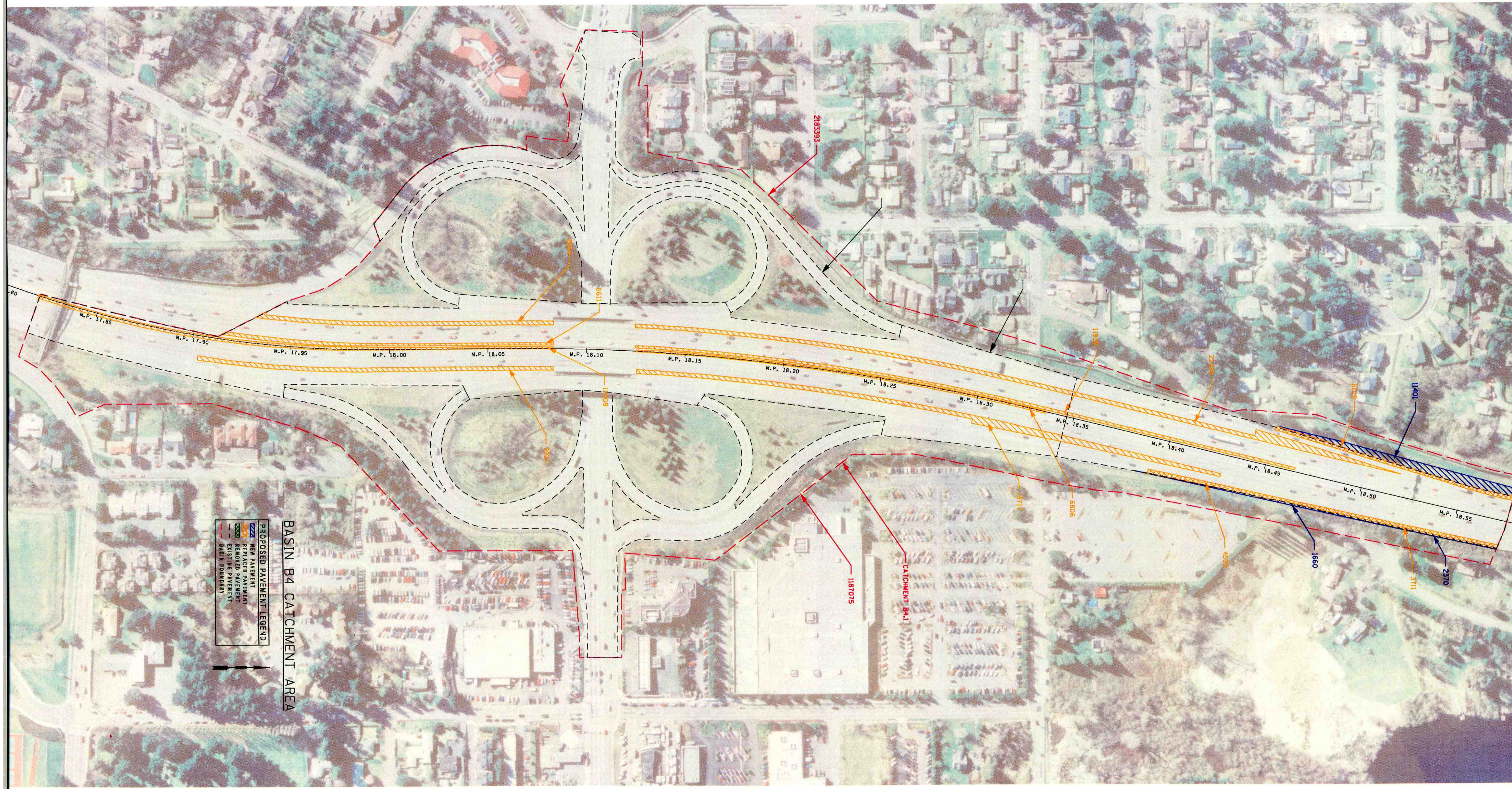


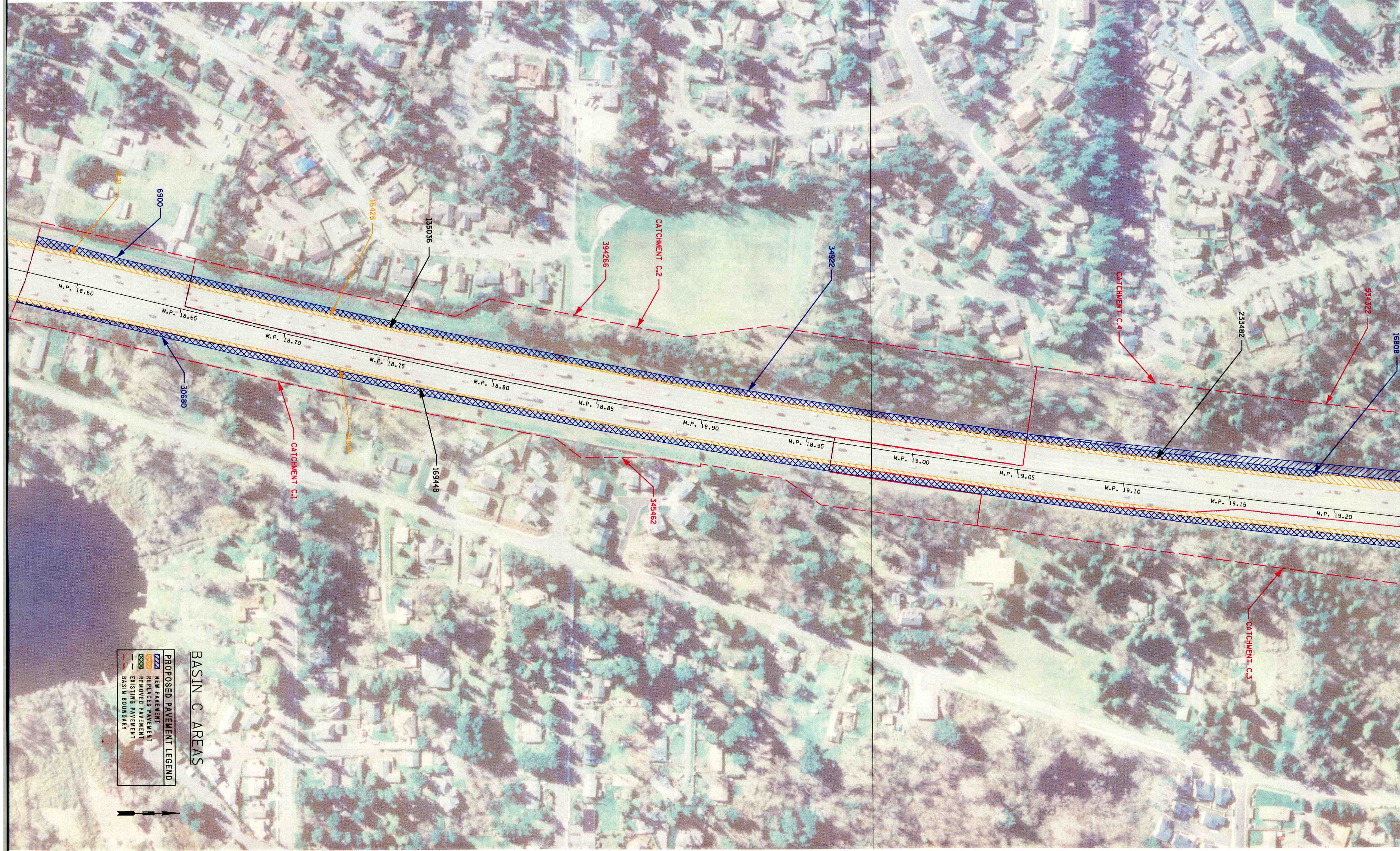
M.P. 15.35
M.P. 15.40
M.P. 15.45
M.P. 15.50
M.P. 15.55
M.P. 15.60
M.P. 15.65
M.P. 15.70
M.P. 15.75
M.P. 15.80
M.P. 15.85
M.P. 15.90
M.P. 15.95
M.P. 16.00
M.P. 16.05
BASIN A AREAS
PG 2
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY


BASIN A AREAS
PG 3
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
M.P. 16.10
M.P. 16.15
M.P. 16.20
M.P. 16.25
M.P. 16.30
M.P. 16.35
M.P. 16.40
M.P. 16.45
M.P. 16.50
M.P. 16.55
M.P. 16.60
M.P. 16.65
M.P. 16.70
M.P. 16.75
M.P. 16.80
47147
19270
350381
CATCHMENT A1.1
BASIN A1
3066123
4954974
BASIN A2
285321
171352
2190



BASIN A1 CATCHMENT AREA
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
M.P. 15.90
M.P. 15.95
M.P. 16.00
M.P. 16.05
M.P. 16.10
M.P. 16.15
M.P. 16.20
M.P. 16.25
M.P. 16.30
M.P. 16.35
M.P. 16.40
M.P. 16.45
M.P. 16.50
M.P. 16.55
12090
47147
350381
CATCHMENT A1.1
3066123


BASIN B4 CATCHMENT AREA
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
M.P. 17.85
M.P. 17.90
M.P. 17.95
M.P. 18.00
M.P. 18.05
M.P. 18.10
M.P. 18.15
M.P. 18.20
M.P. 18.25
M.P. 18.30
M.P. 18.35
M.P. 18.40
M.P. 18.45
M.P. 18.50
M.P. 18.55
2183393
1181075
CATCHMENT B4-1
6806
11401
1660
2370
3711


BASIN C AREAS
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
CATCHMENT C.1
CATCHMENT C.2
CATCHMENT C.3
CATCHMENT C.4
M.P. 18.60
M.P. 18.65
M.P. 18.70
M.P. 18.75
M.P. 18.80
M.P. 18.85
M.P. 18.90
M.P. 18.95
M.P. 19.00
M.P. 19.05
M.P. 19.10
M.P. 19.15
M.P. 19.20
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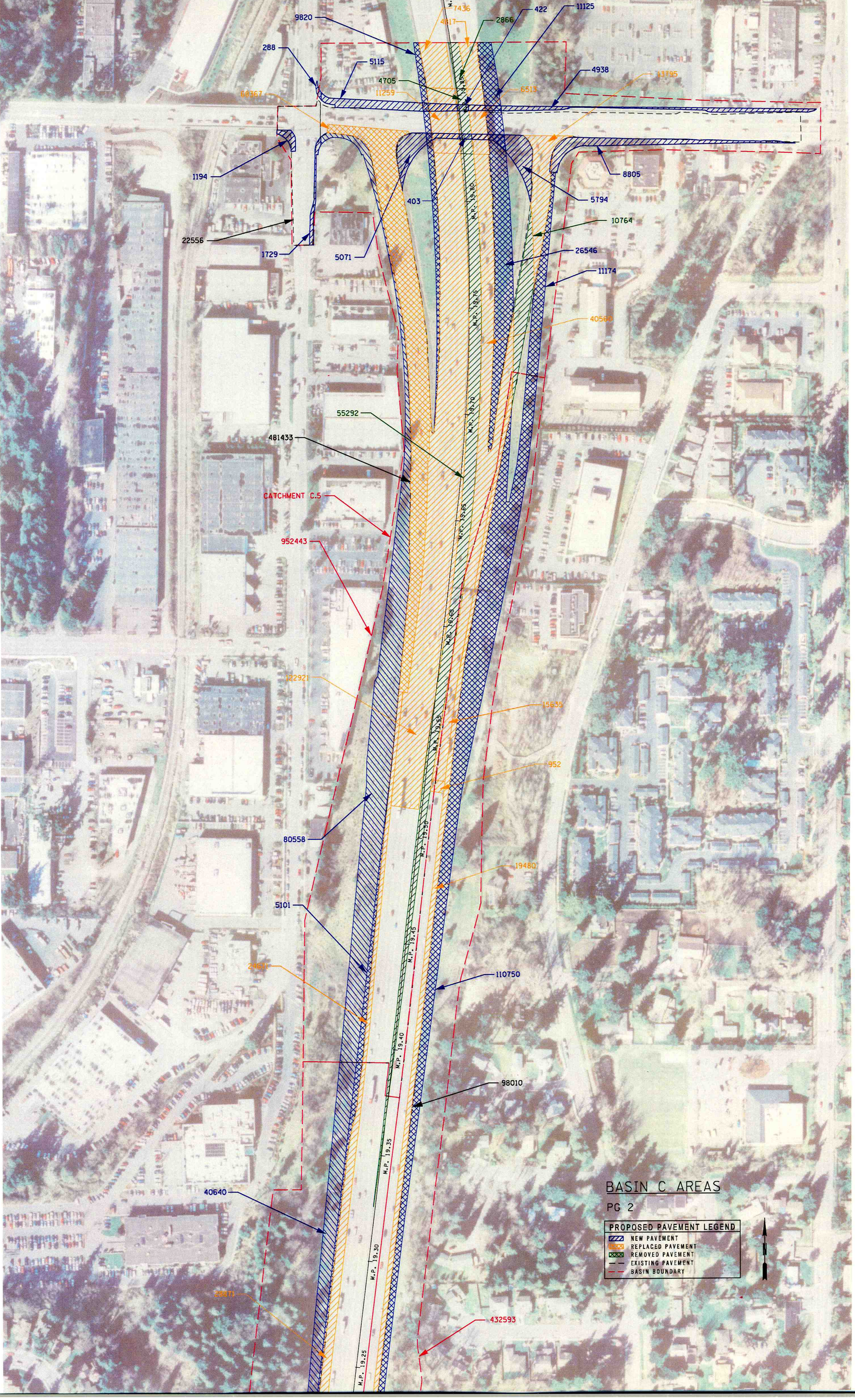
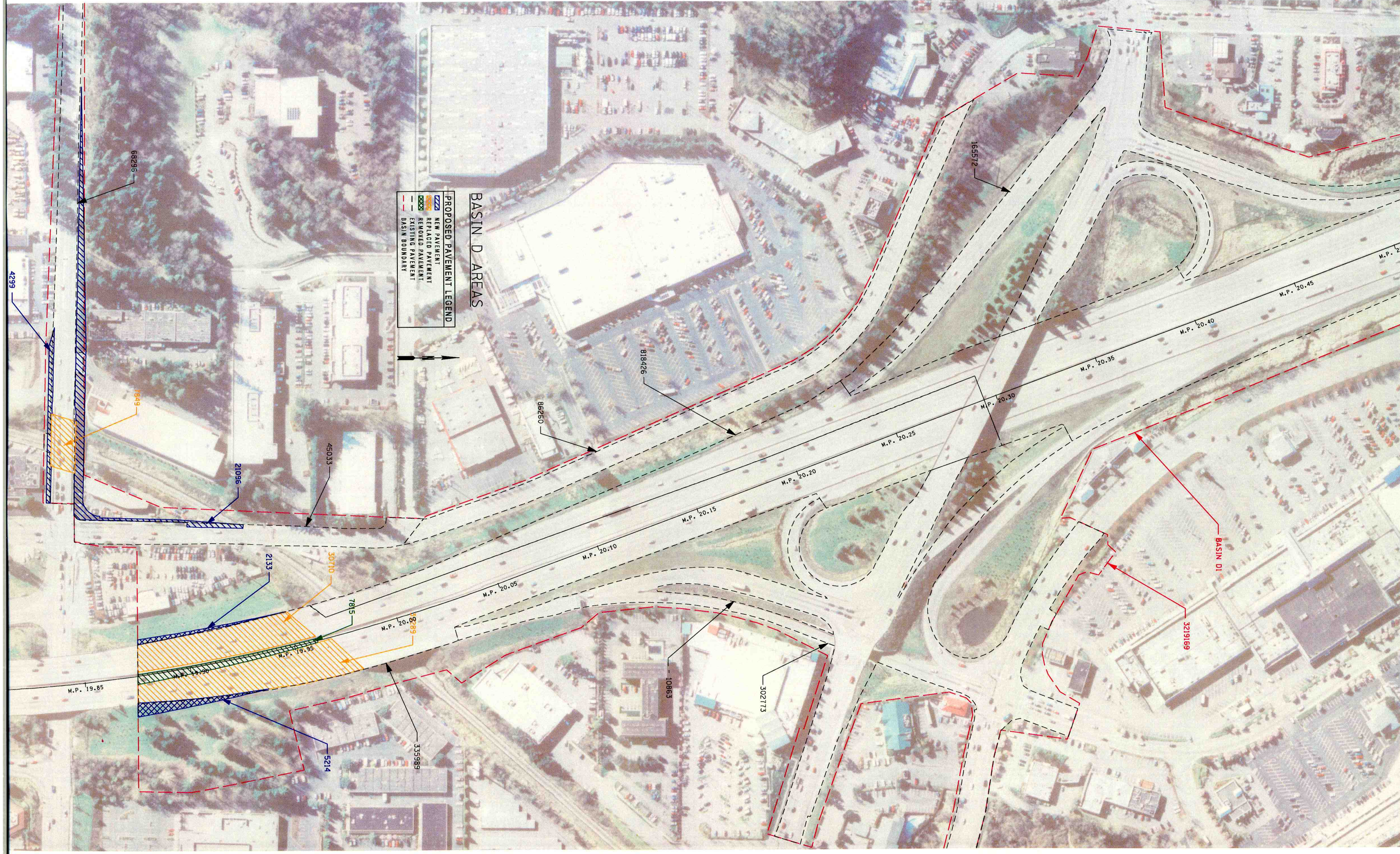
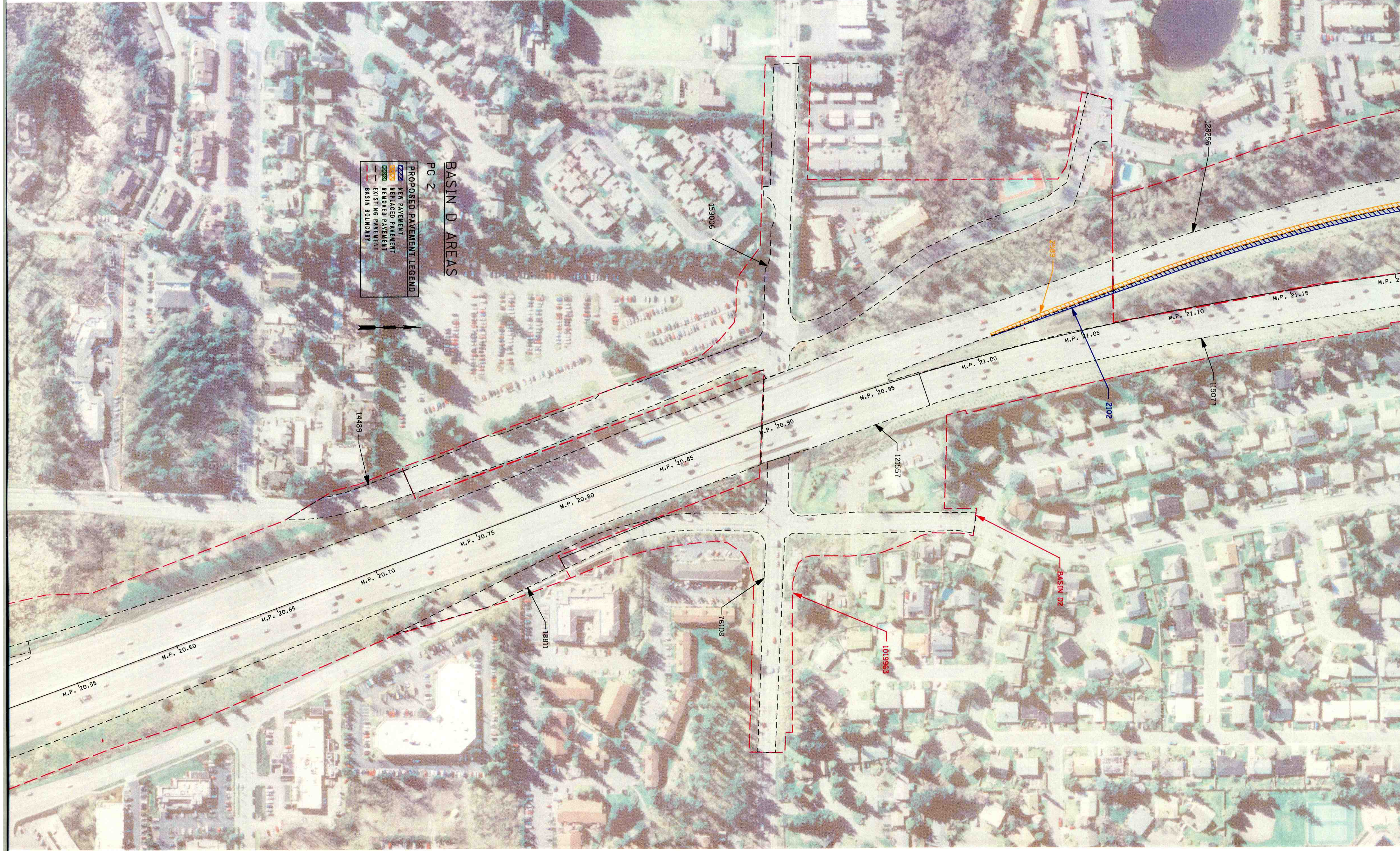
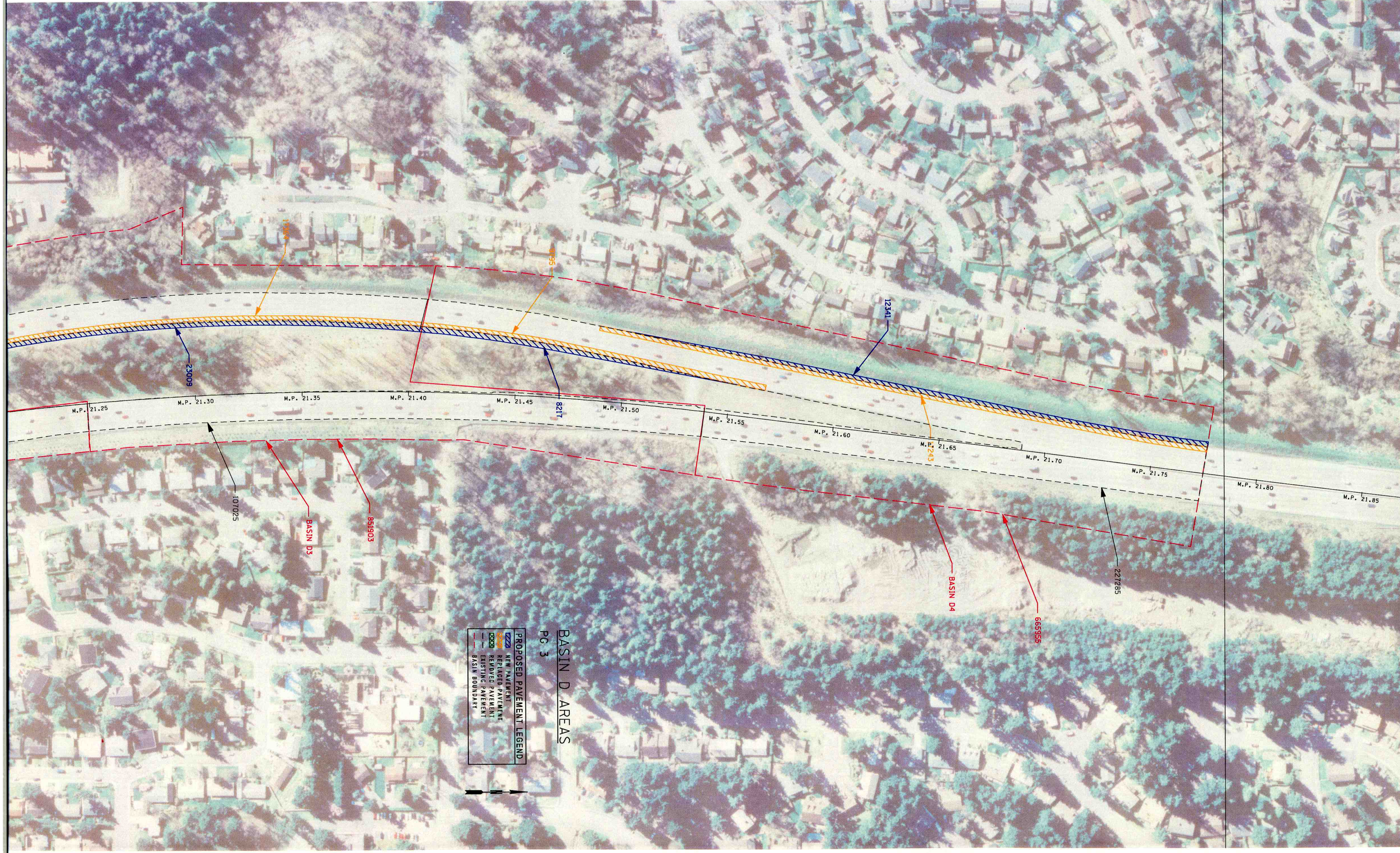
135036
394266
34922
233482
30680
169448
345462


BASIN C AREAS
PG 2
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
CATCHMENT C.5
9820
288
5115
4705
11259
422
2866
11125
4938
6513
1194
22556
1729
5071
403
5794
8805
10764
26546
11174
40568
55292
481433
952443
122921
15635
952
80558
19480
5101
110750
98010
40640
432593
M.P. 19.25
M.P. 19.30
M.P. 19.35
M.P. 19.40
M.P. 19.45
M.P. 19.50
M.P. 19.55
M.P. 19.60
M.P. 19.65
M.P. 19.70
M.P. 19.75
M.P. 19.80

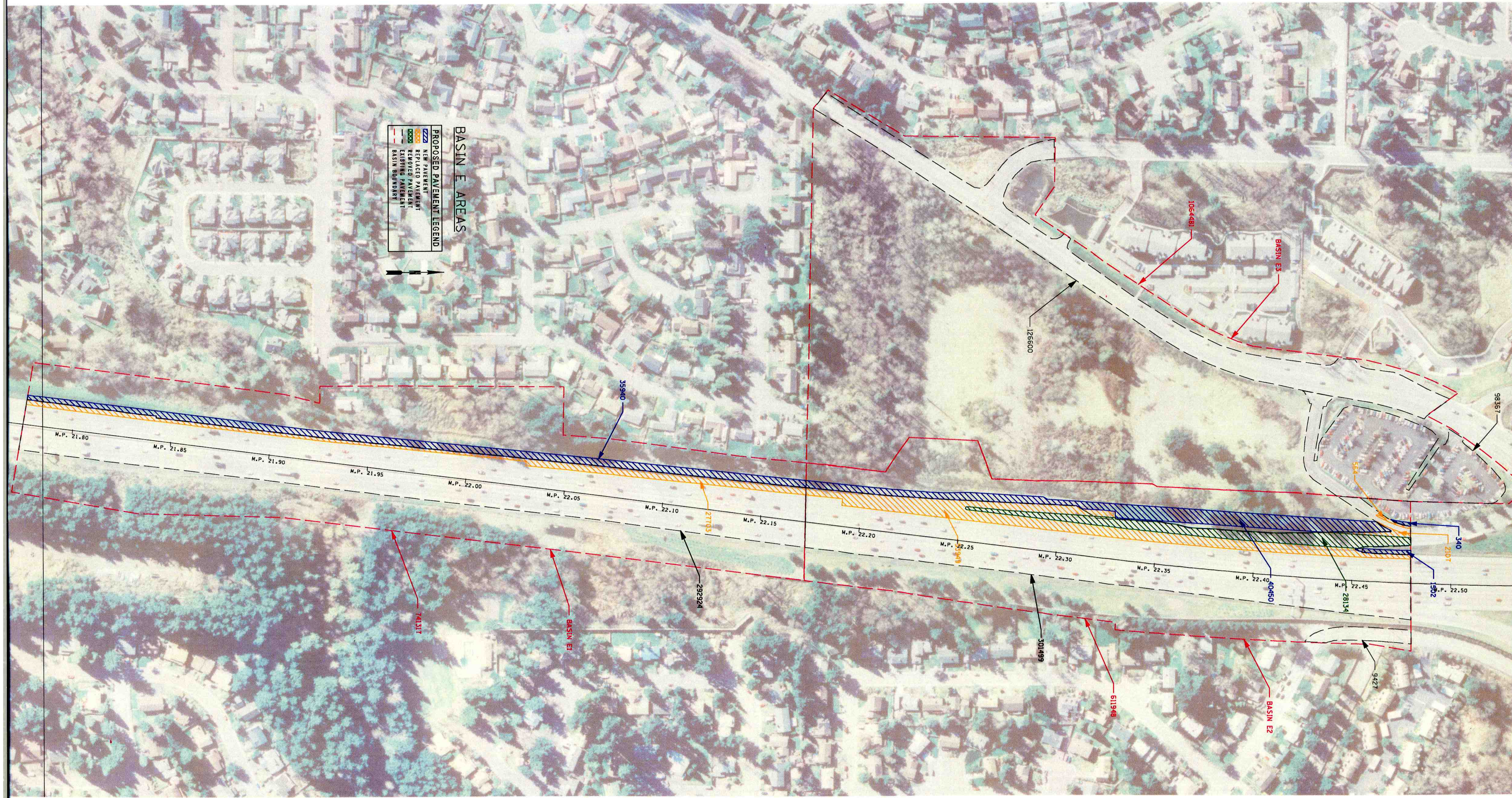


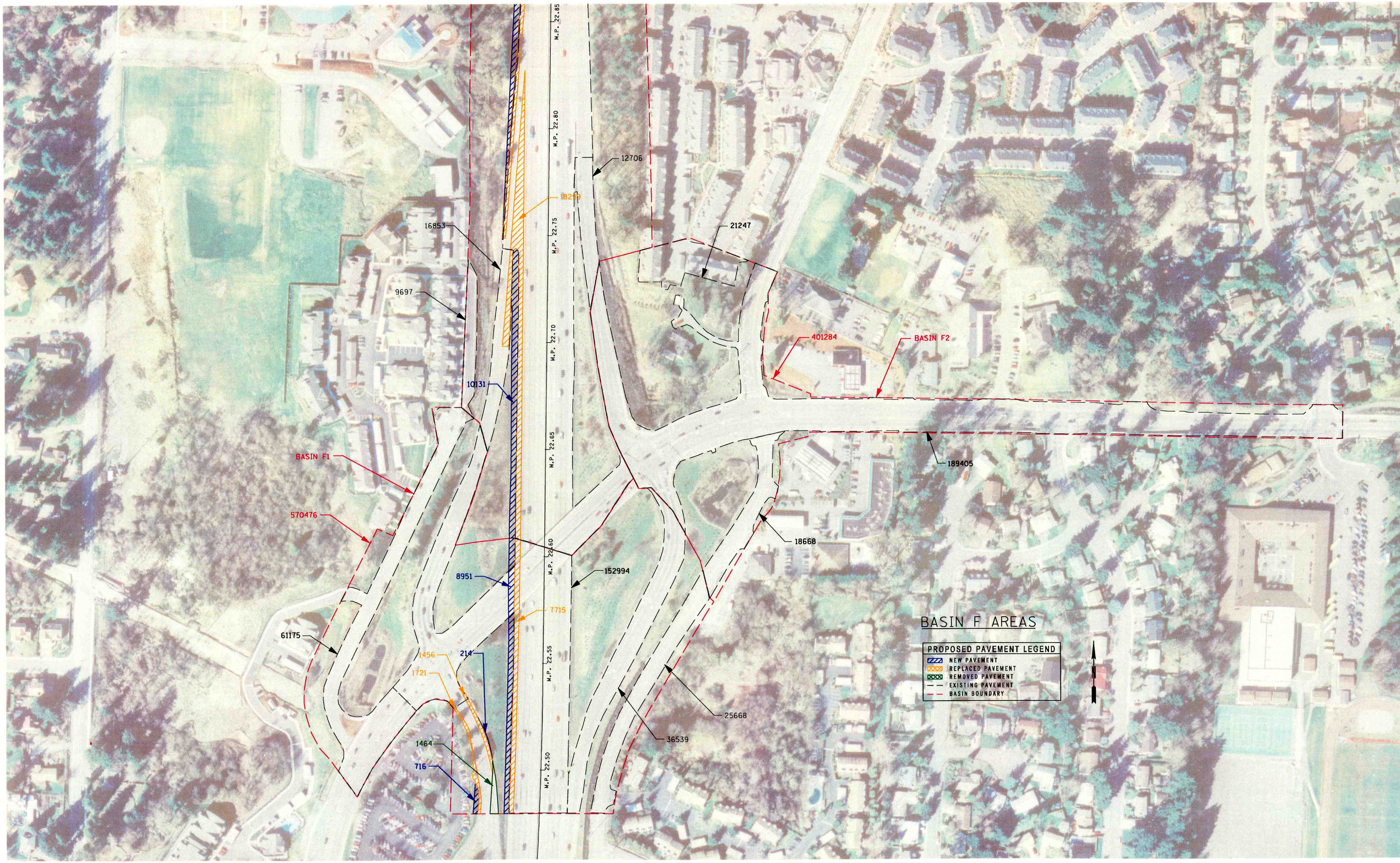
BASIN D AREAS
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
68296
4299
1849
21096
45033
86250
818426
165572
2133
30710
7815
335989
5214
10863
302773
3219169
BASIN D1
M.P. 19.85
M.P. 19.90
M.P. 19.95
M.P. 20.00
M.P. 20.05
M.P. 20.10
M.P. 20.15
M.P. 20.20
M.P. 20.25
M.P. 20.30
M.P. 20.35
M.P. 20.40
M.P. 20.45


BASIN D AREAS
PG 2
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
M.P. 20.55
M.P. 20.60
M.P. 20.65
M.P. 20.70
M.P. 20.75
M.P. 20.80
M.P. 20.85
M.P. 20.90
M.P. 20.95
M.P. 21.00
M.P. 21.05
M.P. 21.10
M.P. 21.15
159006
128256
14489
121557
115077
2102
BASIN D2
18881
76108
1019963



BASIN D AREAS
PG 3
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
N
M.P. 21.25
M.P. 21.30
M.P. 21.35
M.P. 21.40
M.P. 21.45
M.P. 21.50
M.P. 21.55
M.P. 21.60
M.P. 21.65
M.P. 21.70
M.P. 21.75
M.P. 21.80
M.P. 21.85
23009
8217
12341
107025
BASIN D3
851903
BASIN D4
665955
227285

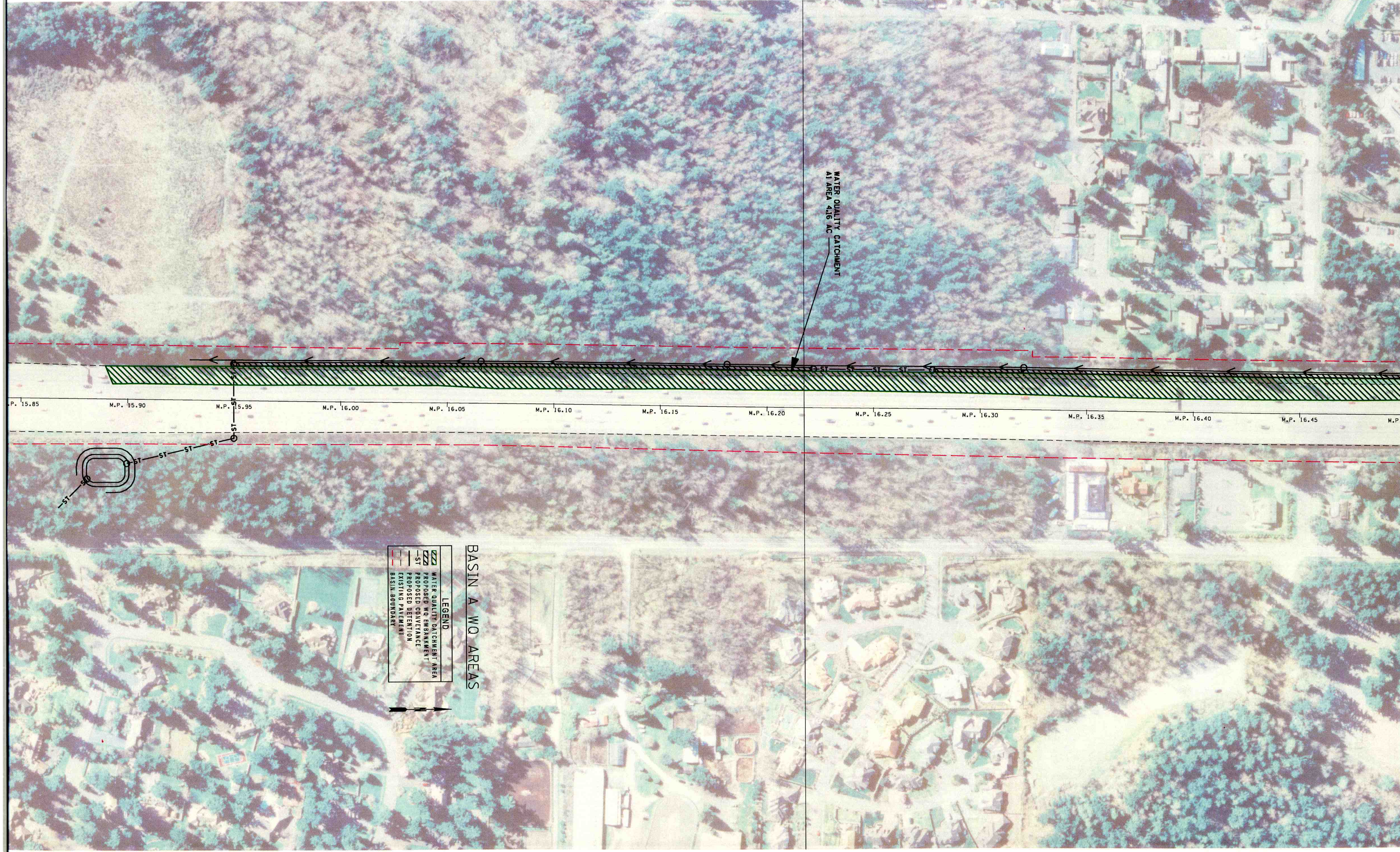

BASIN E AREAS
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
M.P. 21.80
M.P. 21.85
M.P. 21.90
M.P. 21.95
M.P. 22.00
M.P. 22.05
M.P. 22.10
M.P. 22.15
M.P. 22.20
M.P. 22.25
M.P. 22.30
M.P. 22.35
M.P. 22.40
M.P. 22.45
M.P. 22.50
BASIN E1
BASIN E2
BASIN E3
35940
292924
126600
98367
340
40450
28134
301499
611948
9427



BASIN F AREAS
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
BASIN F1
BASIN F2
M.P. 22.85
M.P. 22.80
M.P. 22.75
M.P. 22.70
M.P. 22.65
M.P. 22.60
M.P. 22.55
M.P. 22.50
12706
18299
16853
21247
9697
401284
10131
189405
570476
18668
8951
152994
7715
61175
1456
214
1721
1464
716
25668
36539

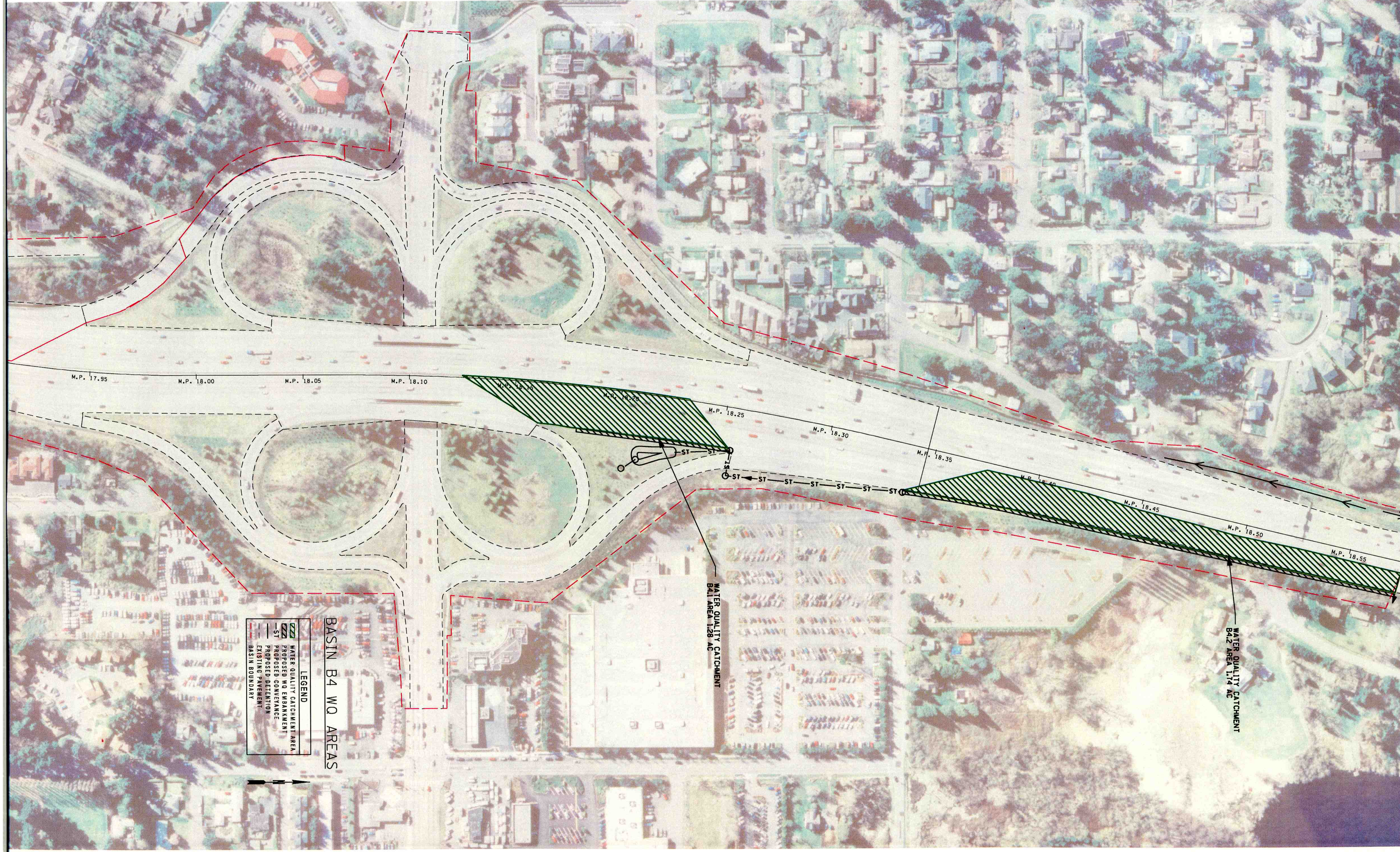
BASIN F AREAS
PG 2
PROPOSED PAVEMENT LEGEND
NEW PAVEMENT
REPLACED PAVEMENT
REMOVED PAVEMENT
EXISTING PAVEMENT
BASIN BOUNDARY
24495
750524
BASIN F4
281970
20348
454
431192
1126038
BASIN F3
M.P. 22.90
M.P. 22.95
M.P. 23.00
M.P. 23.05
M.P. 23.10
M.P. 23.15
M.P. 23.20
M.P. 23.25
M.P. 23.30
M.P. 23.35
M.P. 23.40
M.P. 23.45
M.P. 23.50

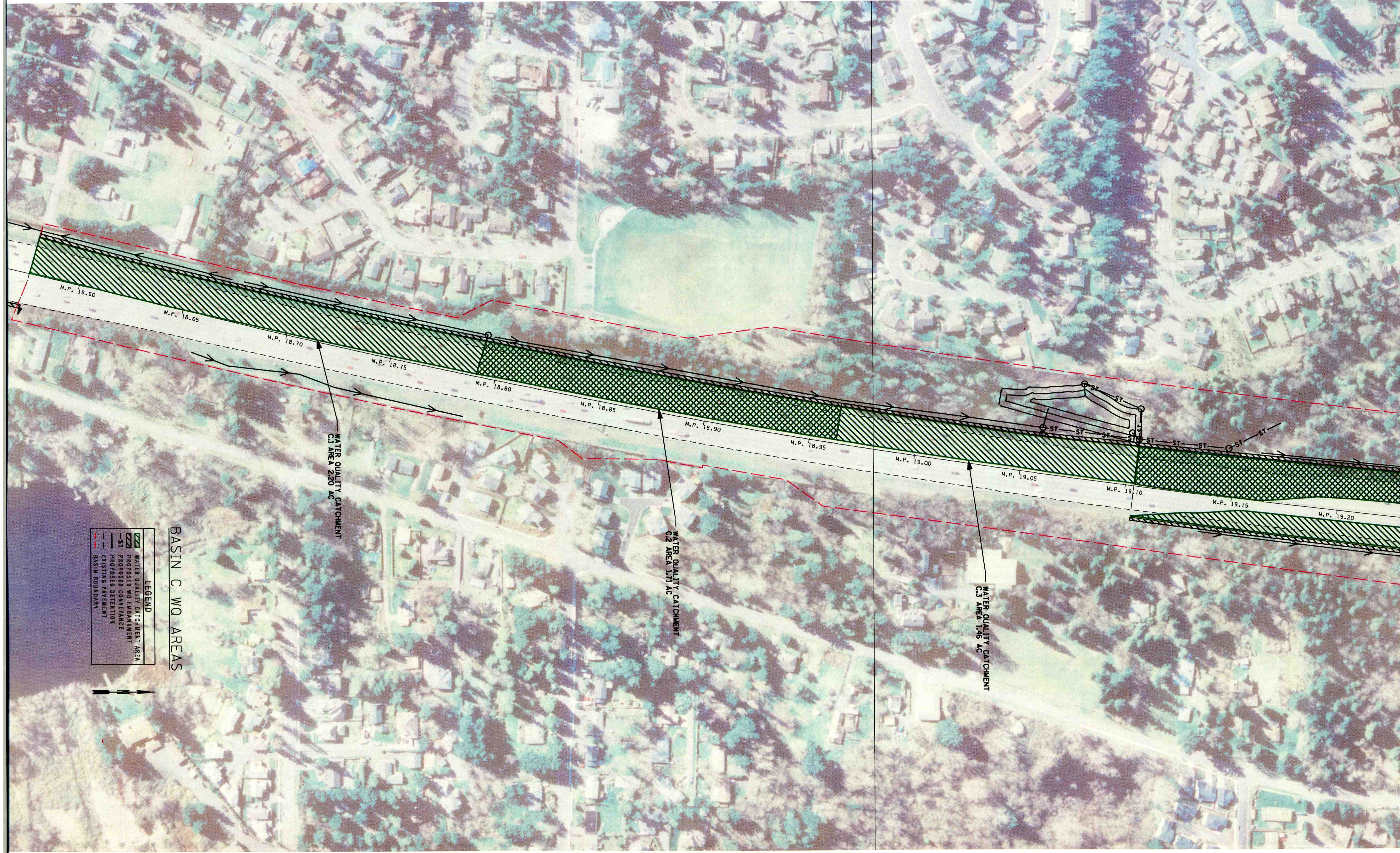
WATER QUALITY AREA DRAWINGS

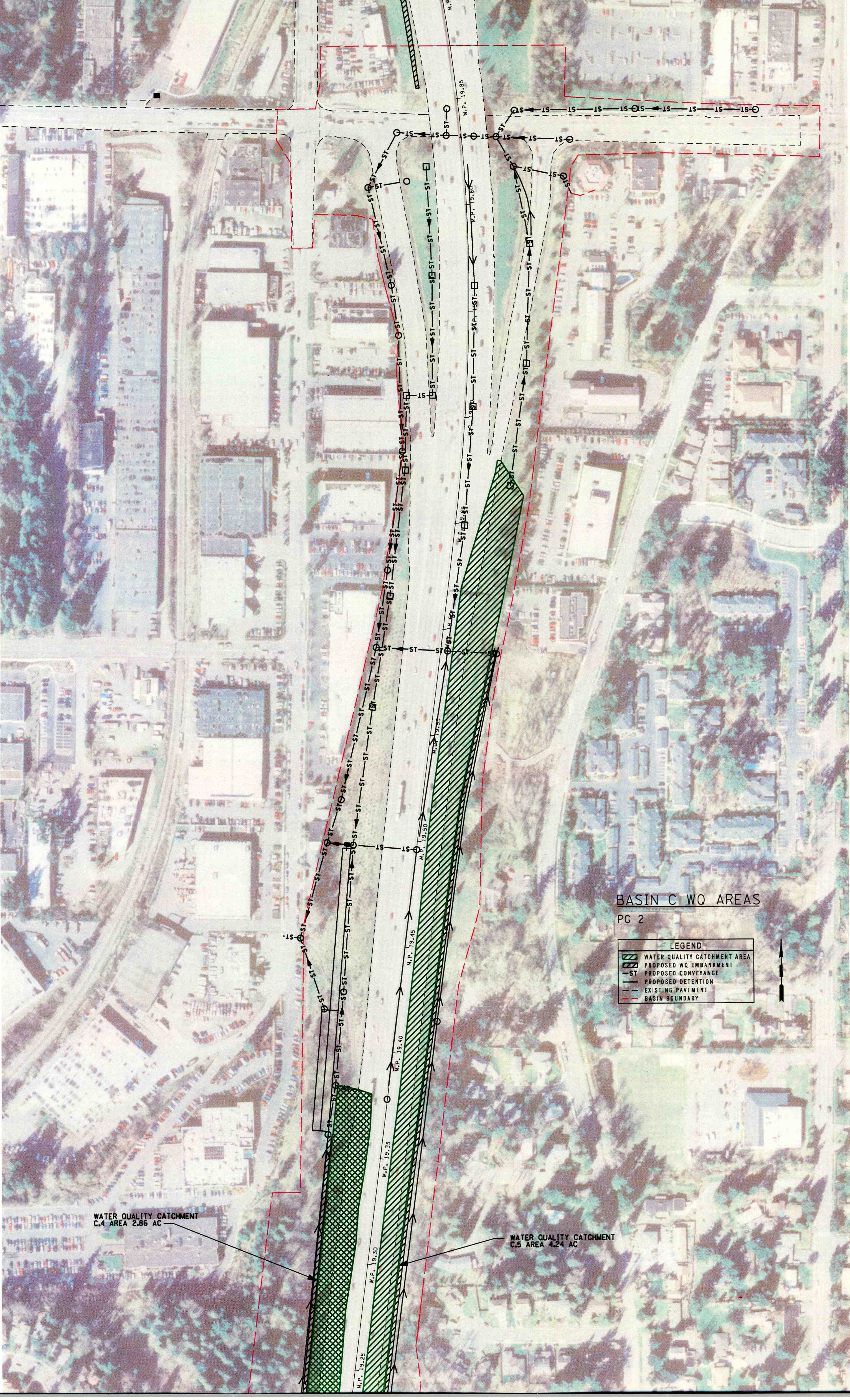


WATER QUALITY CATCHMENT
A1 AREA 4.16 AC
M.P. 15.85
M.P. 15.90
M.P. 15.95
M.P. 16.00
M.P. 16.05
M.P. 16.10
M.P. 16.15
M.P. 16.20
M.P. 16.25
M.P. 16.30
M.P. 16.35
M.P. 16.40
M.P. 16.45
ST
BASIN A WQ AREAS
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
ST PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY

WATER QUALITY CATCHMENT
A2 AREA 1.39 AC
M.P. 16.55
M.P. 16.60
M.P. 16.65
M.P. 16.70
M.P. 16.75
M.P. 16.80
M.P. 16.85
M.P. 16.90
M.P. 16.95
M.P. 17.00
M.P. 17.05
M.P. 17.10
M.P. 17.15
BASIN A WQ AREAS
PG 2
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
ST PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY


BASIN B4 WQ AREAS
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY
WATER QUALITY CATCHMENT
B4.1 AREA 1.28 AC
WATER QUALITY CATCHMENT
B4.2 AREA 1.74 AC
M.P. 17.95
M.P. 18.00
M.P. 18.05
M.P. 18.10
M.P. 18.20
M.P. 18.25
M.P. 18.30
M.P. 18.35
M.P. 18.45
M.P. 18.50
M.P. 18.55


BASIN C WQ AREAS
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
ST PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY
WATER QUALITY CATCHMENT
C1 AREA 2.20 AC
WATER QUALITY CATCHMENT
C2 AREA 1.71 AC
WATER QUALITY CATCHMENT
C3 AREA 1.46 AC
M.P. 18.60
M.P. 18.65
M.P. 18.70
M.P. 18.75
M.P. 18.80
M.P. 18.85
M.P. 18.90
M.P. 18.95
M.P. 19.00
M.P. 19.05
M.P. 19.10
M.P. 19.15
M.P. 19.20


BASIN C WQ AREAS
PG 2
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY
WATER QUALITY CATCHMENT
C.4 AREA 2.86 AC
WATER QUALITY CATCHMENT
C.5 AREA 4.24 AC
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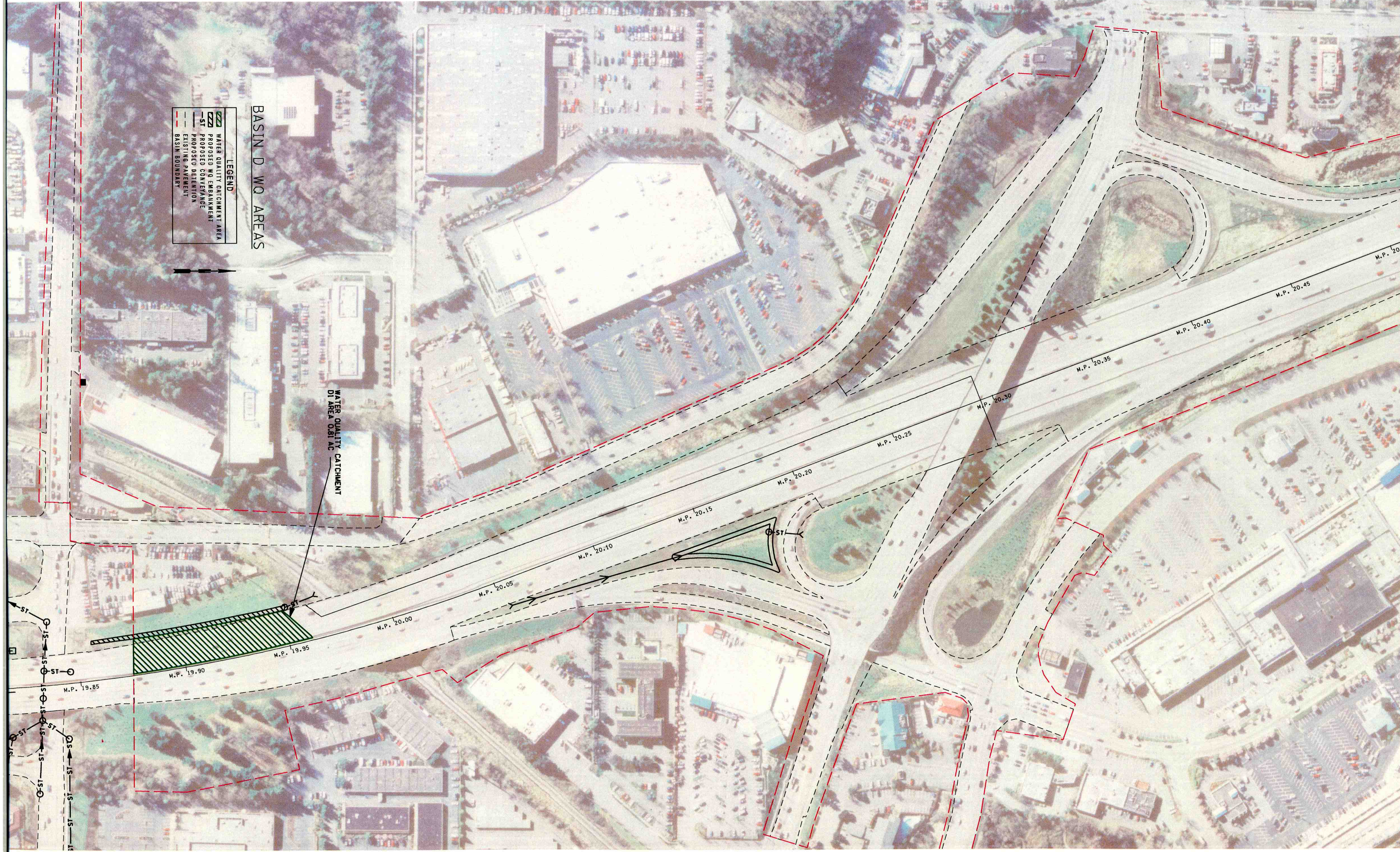
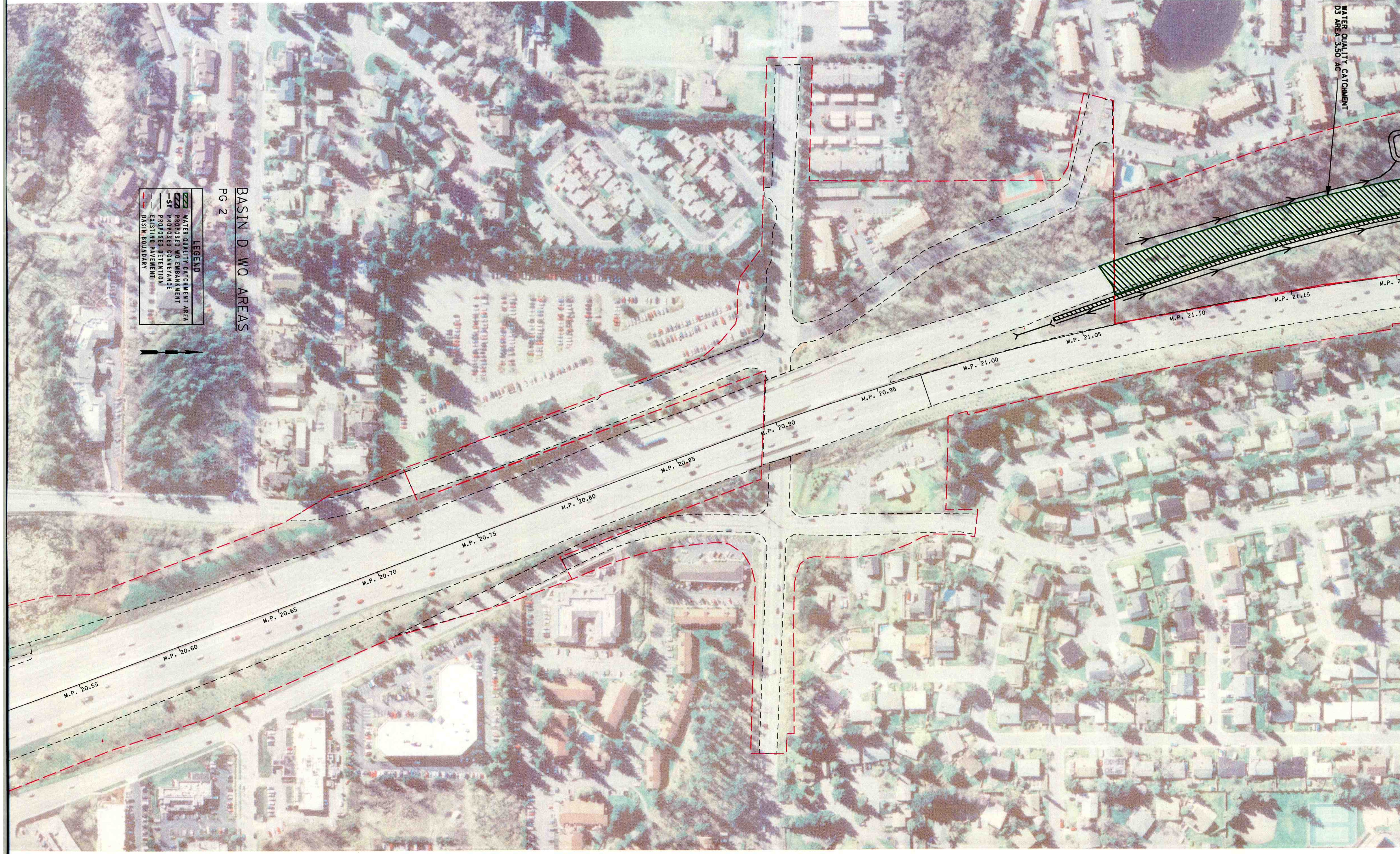
M.P. 19.30
M.P. 19.35
M.P. 19.40
M.P. 19.45
M.P. 19.50
M.P. 19.85



BASIN D WQ AREAS
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY
WATER QUALITY CATCHMENT
DI AREA 0.81 AC
M.P. 19.85
M.P. 19.90
M.P. 19.95
M.P. 20.00
M.P. 20.05
M.P. 20.10
M.P. 20.15
M.P. 20.20
M.P. 20.25
M.P. 20.30
M.P. 20.35
M.P. 20.40
M.P. 20.45



BASIN D WQ AREAS
PG 2
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
—ST PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY
WATER QUALITY CATCHMENT
D3 AREA 3.50 AC
M.P. 20.55
M.P. 20.60
M.P. 20.65
M.P. 20.70
M.P. 20.75
M.P. 20.80
M.P. 20.85
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M.P. 20.95
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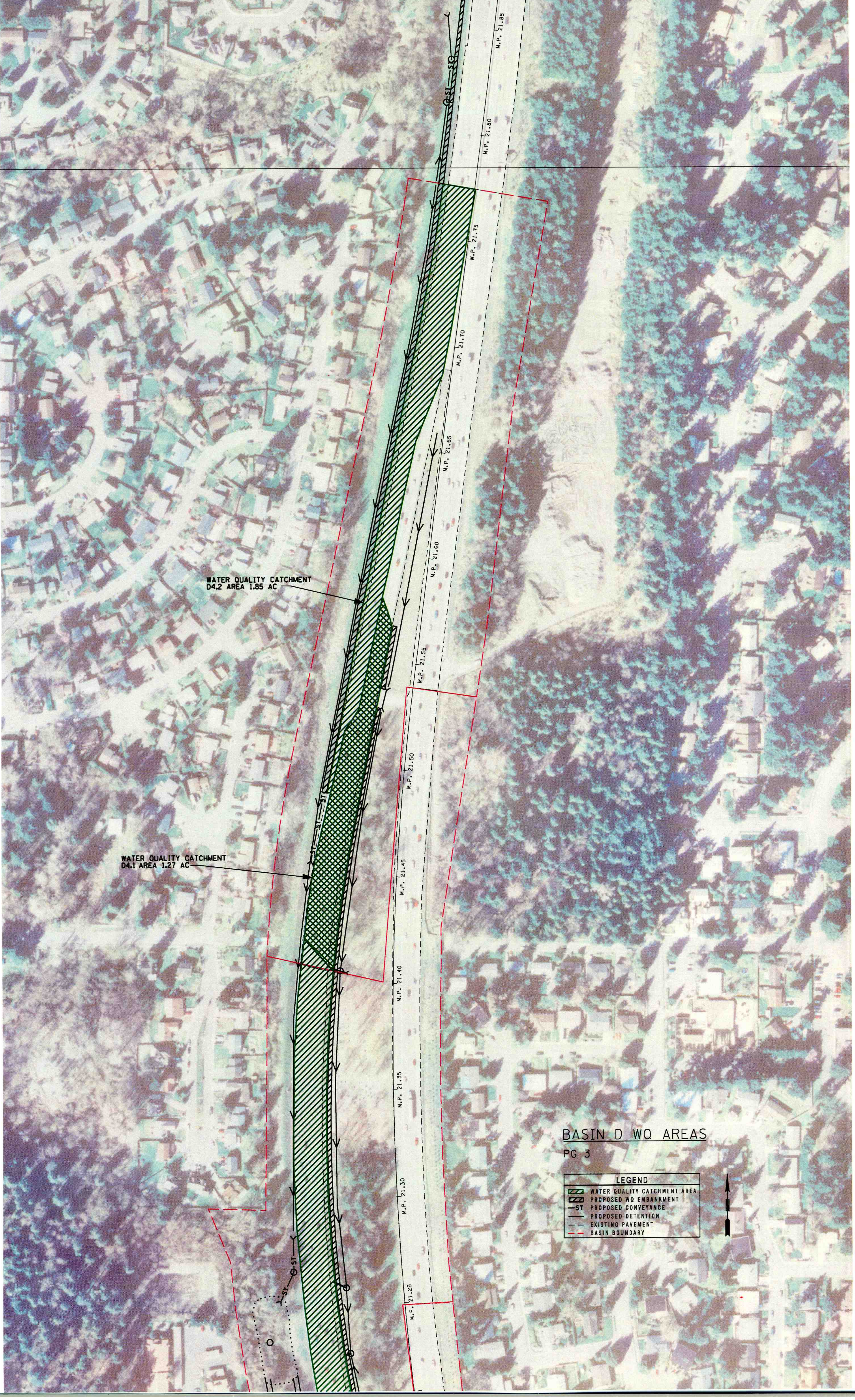
M.P. 21.15



WATER QUALITY CATCHMENT
D4.2 AREA 1.85 AC
WATER QUALITY CATCHMENT
D4.1 AREA 1.27 AC
M.P. 21.25
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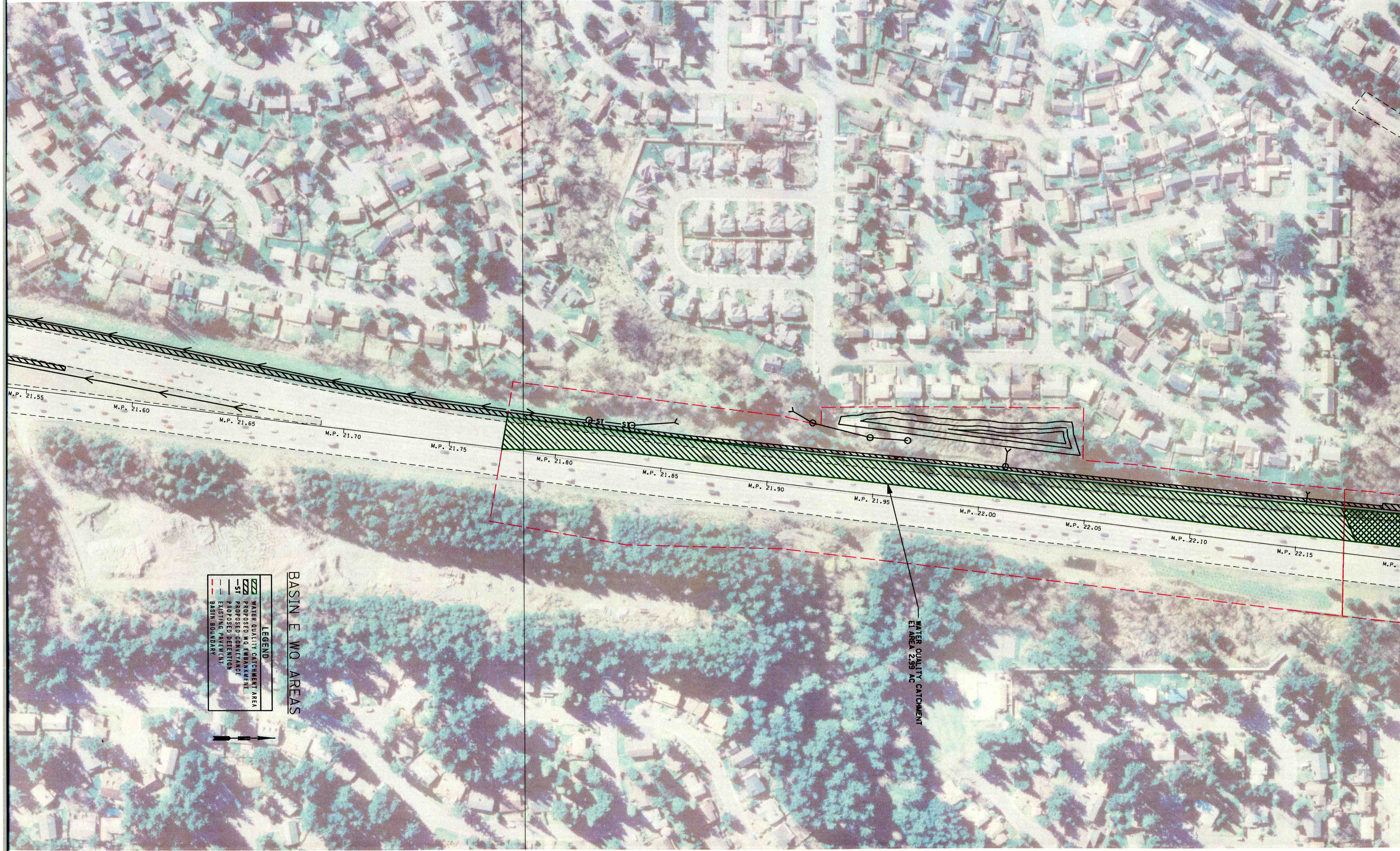
M.P. 21.35
M.P. 21.40
M.P. 21.45
M.P. 21.50
M.P. 21.55
M.P. 21.60
M.P. 21.65
M.P. 21.70
M.P. 21.75
M.P. 21.80
M.P. 21.85
BASIN D WQ AREAS
PG 3
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
ST PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY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ST PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY
WATER QUALITY CATCHMENT E1 AREA 2.99 AC
M.P. 21.55
M.P. 21.60
M.P. 21.65
M.P. 21.70
M.P. 21.75
M.P. 21.80
M.P. 21.85
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M.P. 22.05
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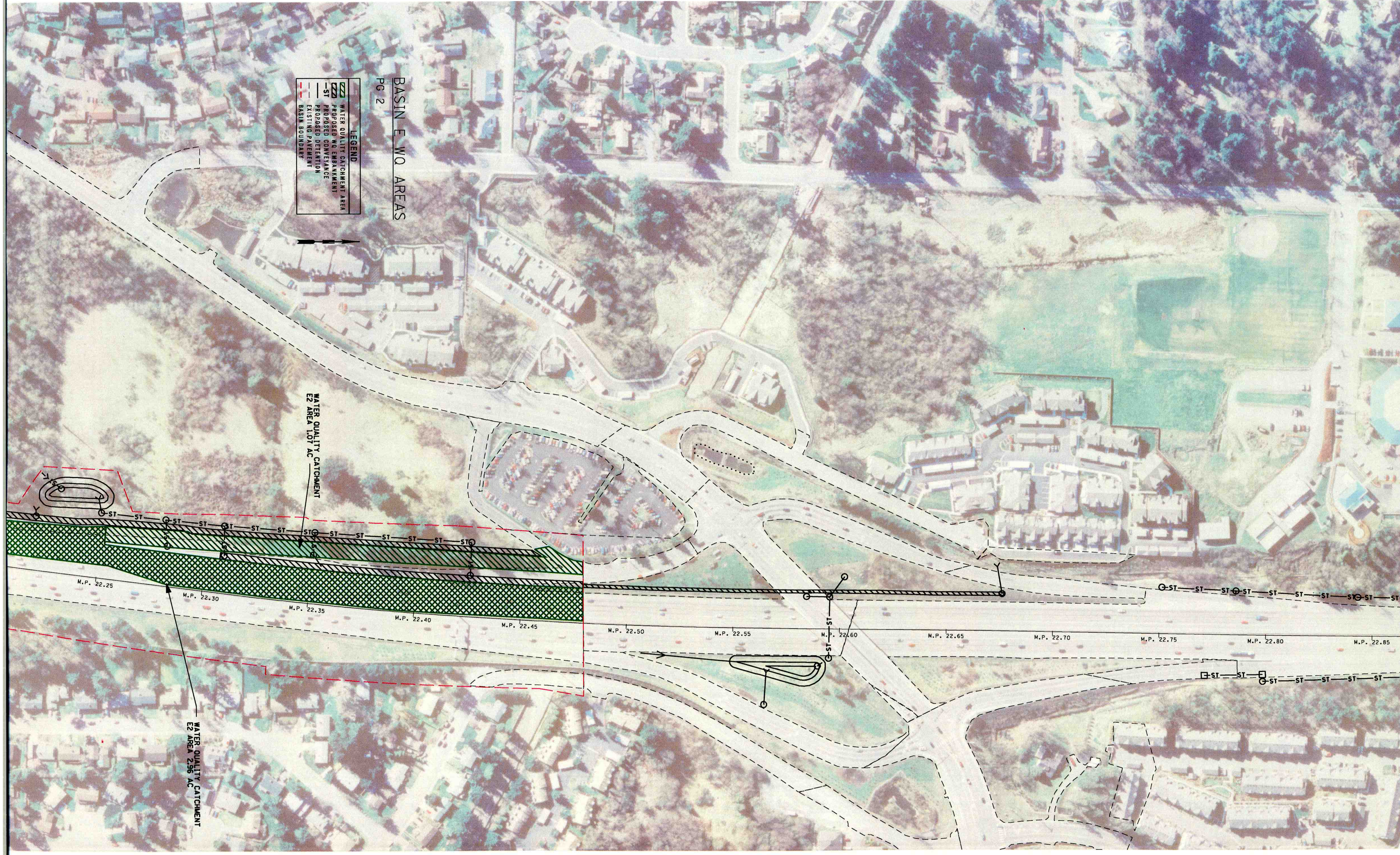
M.P. 22.15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PG 2
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
ST PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY
WATER QUALITY CATCHMENT
E2 AREA 1.07 AC
WATER QUALITY CATCHMENT
E2 AREA 2.36 AC
M.P. 22.25
M.P. 22.30
M.P. 22.35
M.P. 22.40
M.P. 22.45
M.P. 22.50
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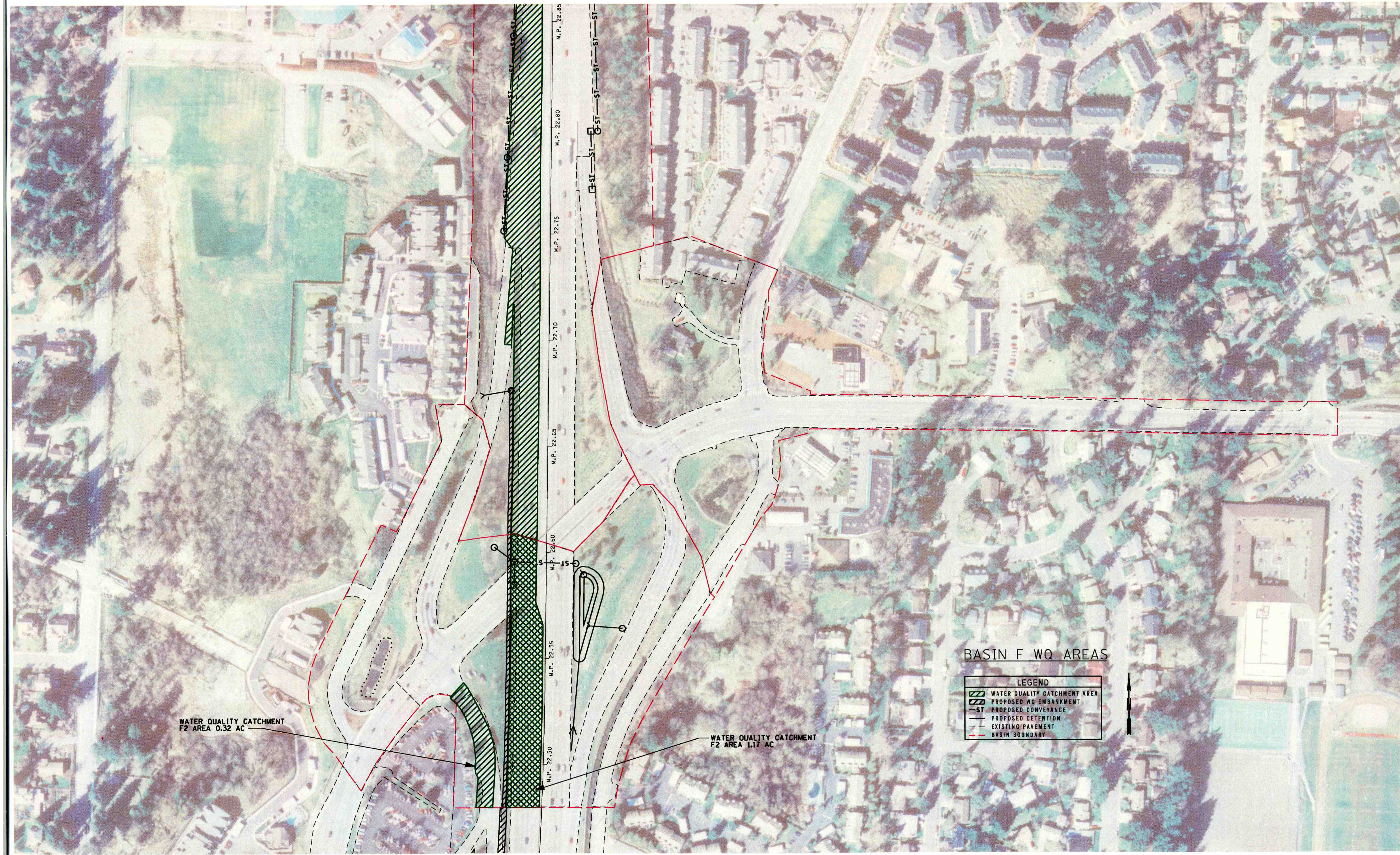
M.P. 22.80
M.P. 22.85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LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
ST PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY
N
WATER QUALITY CATCHMENT
F2 AREA 0.32 AC
WATER QUALITY CATCHMENT
F2 AREA 1.17 AC
M.P. 22.85
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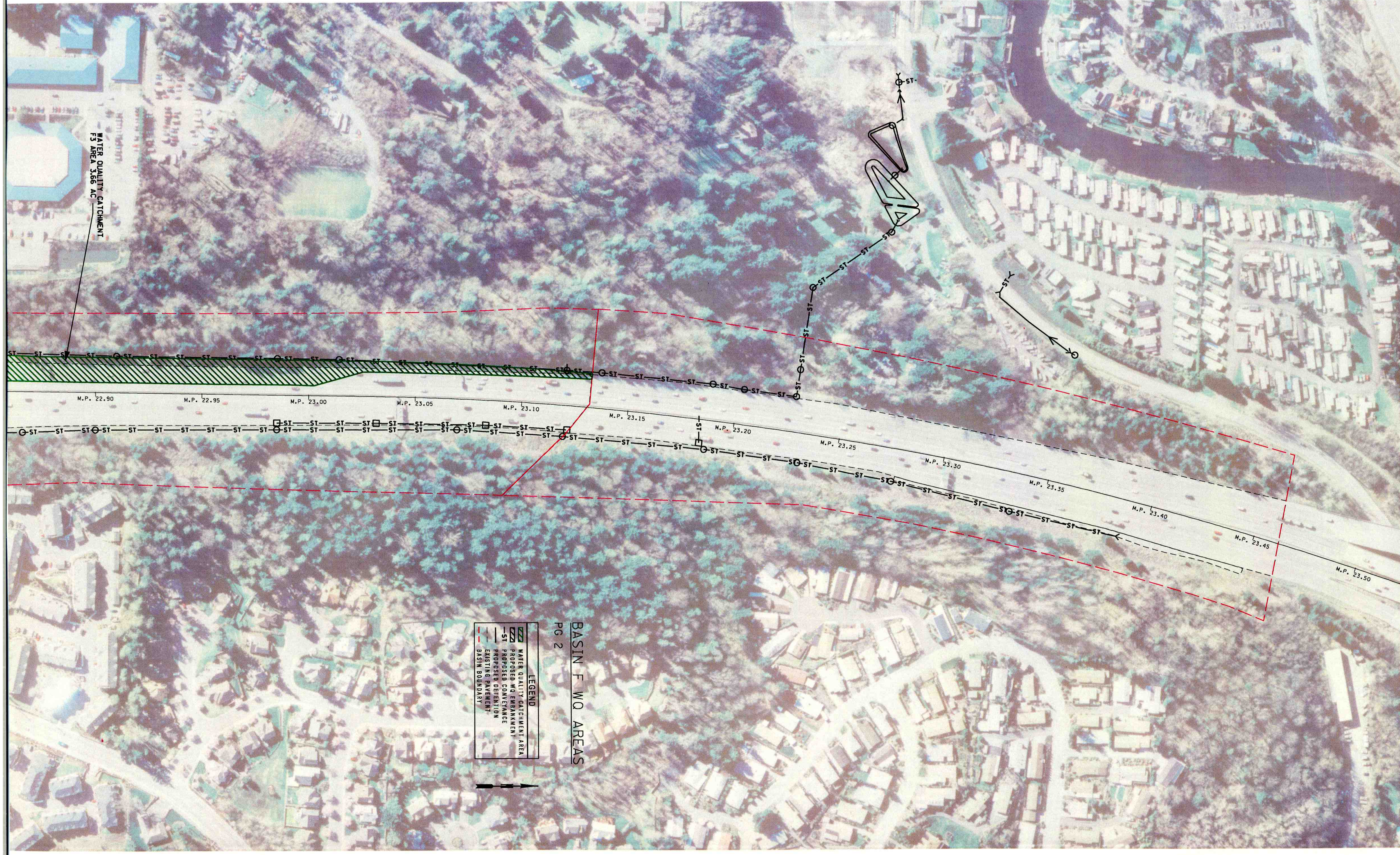

BASIN F WQ AREAS
PG 2
LEGEND
WATER QUALITY CATCHMENT AREA
PROPOSED WQ EMBANKMENT
ST PROPOSED CONVEYANCE
PROPOSED DETENTION
EXISTING PAVEMENT
BASIN BOUNDARY
WATER QUALITY CATCHMENT
F3 AREA 3.66 AC
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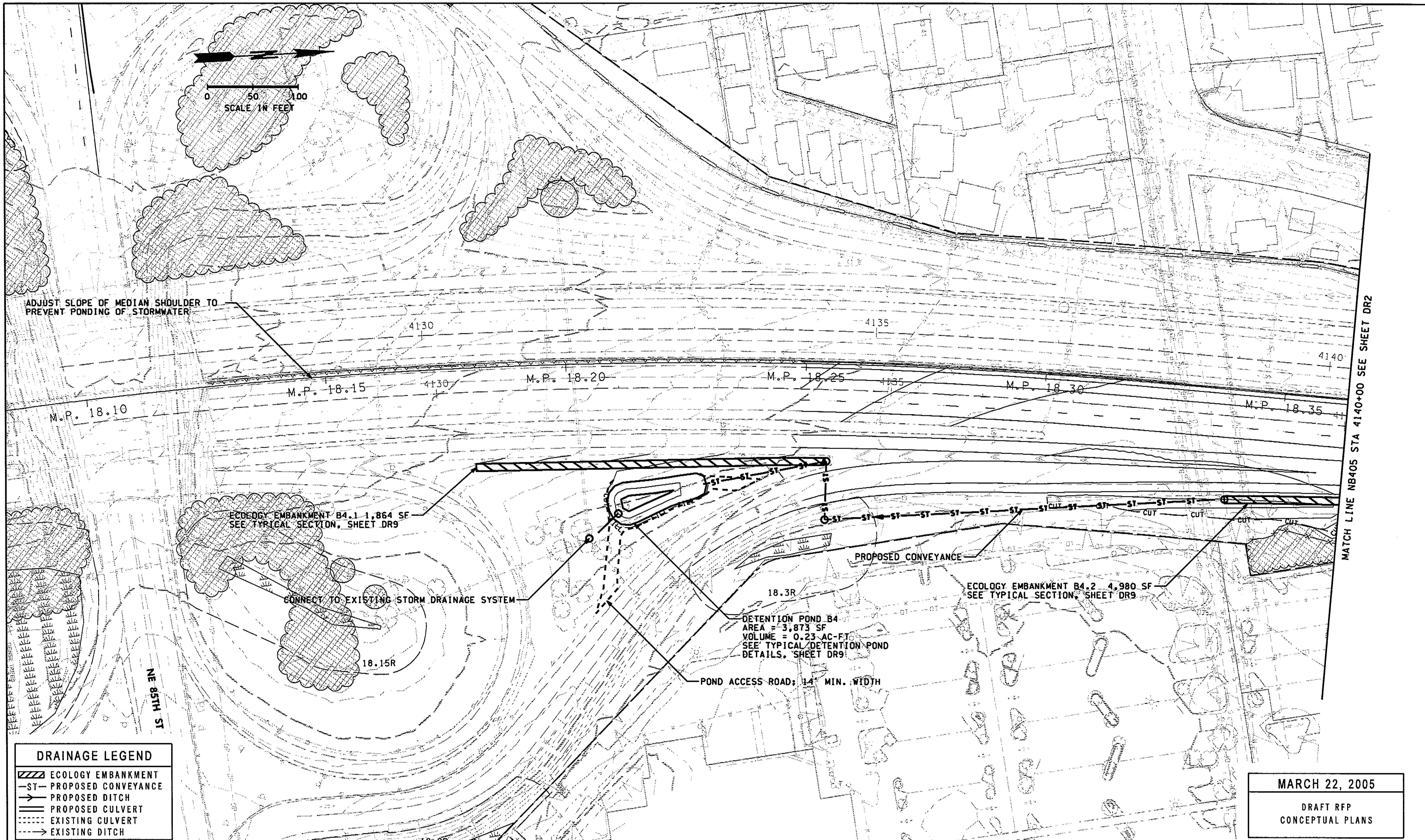
M.P. 22.95
M.P. 23.00
M.P. 23.05
M.P. 23.10
M.P. 23.15
M.P. 23.20
M.P. 23.25
M.P. 23.30
M.P. 23.35
M.P. 23.40
M.P. 23.45
M.P. 23.50

APPENDIX B

DRAINAGE PLANS (PRELIMINARY CONVEYANCE, TREATMENT FACILITIES, SUB-BASINS, EXISTING CONDITIONS, TYPICAL SECTIONS, DETAILS)

STAGE 1 DRAINAGE PLANS



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CHECKED BY	W. TAYLOR				
PROJ. ENGR.	K. HENRY				
REGIONAL ADM.	D. DYE	REVISION	DATE	BY	

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.	LOCATION NO.	

P.E. STAMP BOX DATE

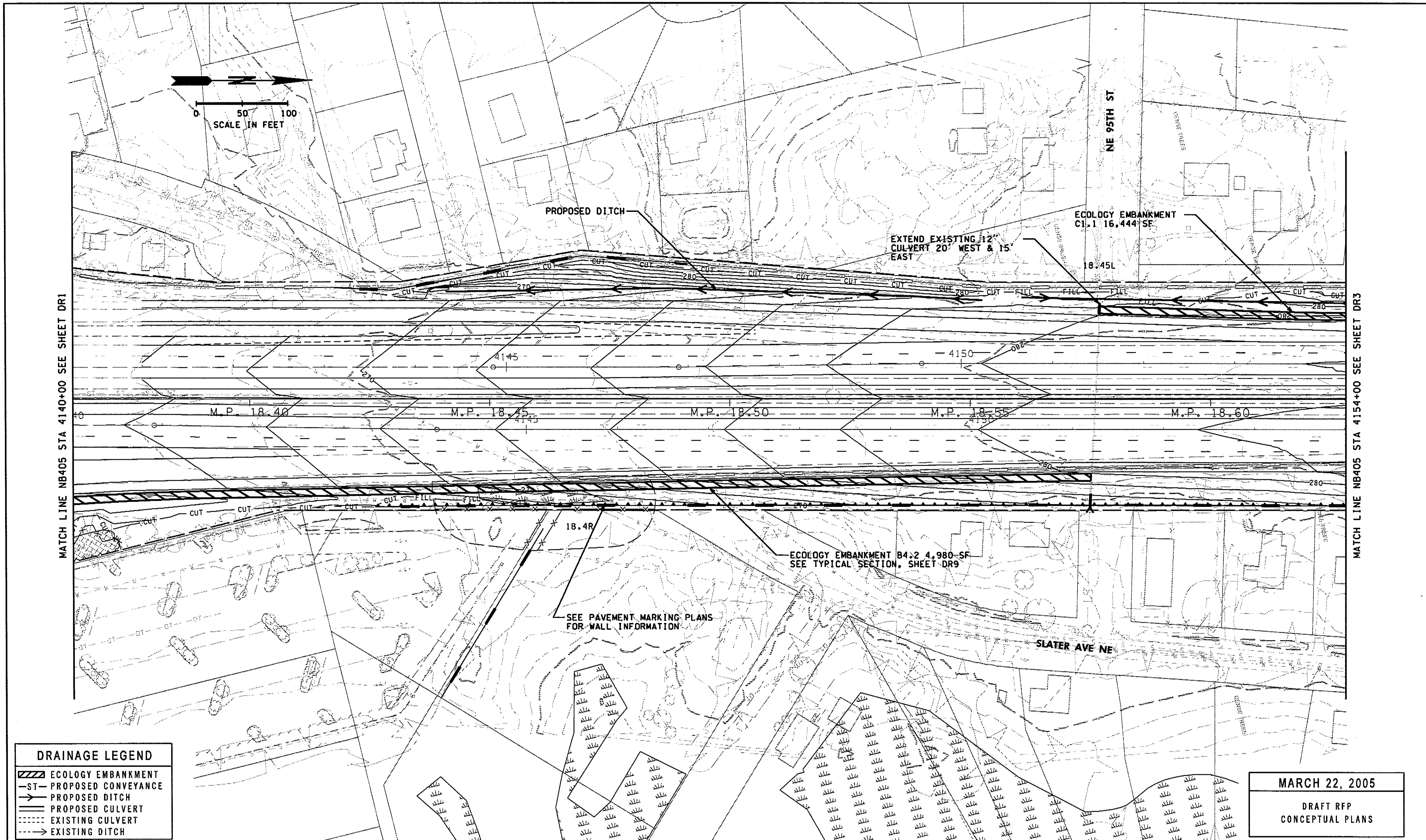
P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405
SR 520 TO SR 522

STAGE 1
DRAINAGE PLAN

DR1
SHEET
OF
SHEETS



MARCH 22, 2005

DRAFT RFP
CONCEPTUAL PLANS

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PROJ. ENGR.	K. HENRY		
REGIONAL ADM.	D. DYE		
	REVISION	DATE	BY

REGION NO. 10 STATE WASH FED.AID PROJ.NO.

JOB NUMBER

CONTRACT NO. LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

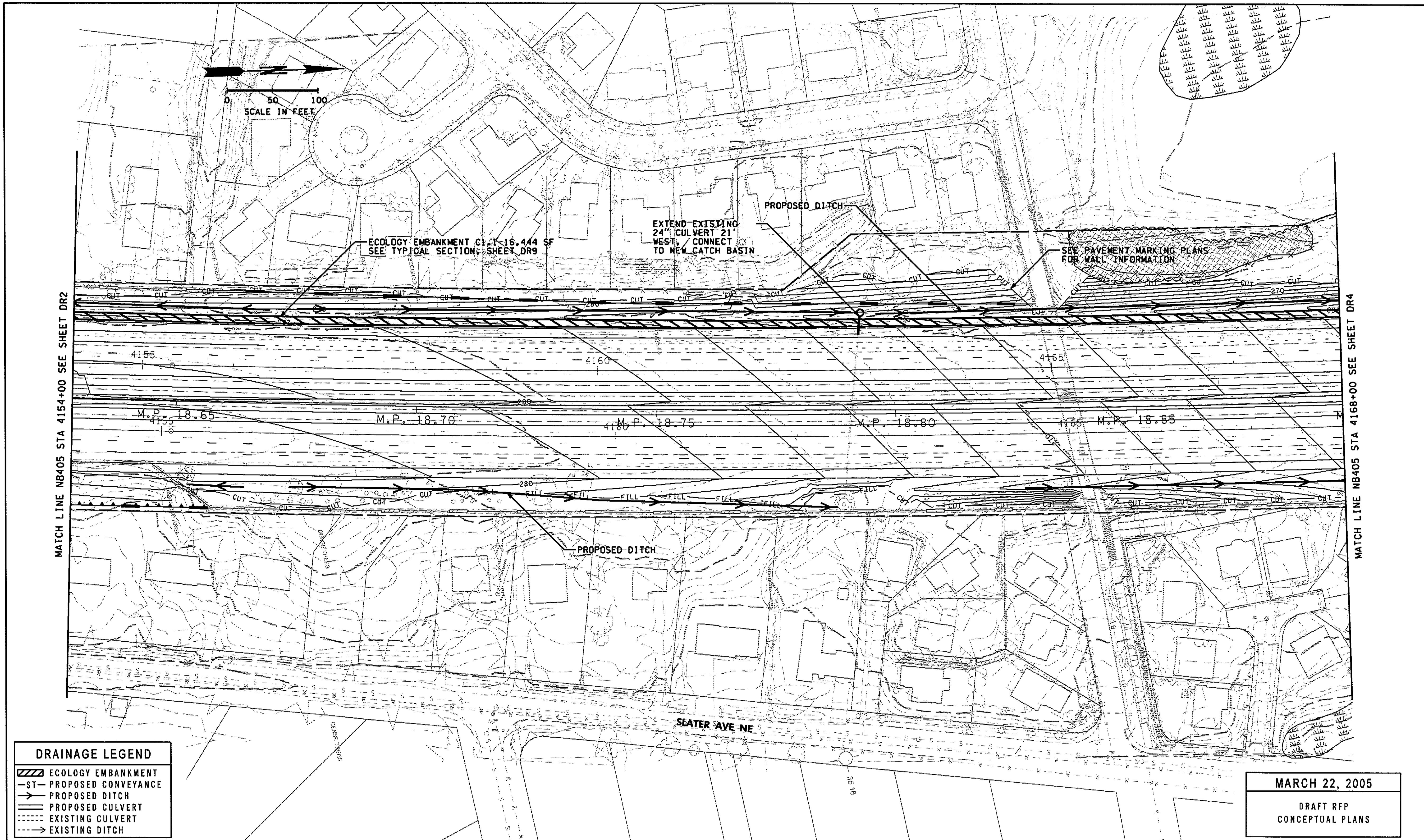
I-405
SR 520 TO SR 522

STAGE 1

DRAINAGE PLAN

DR2

SHEET OF SHEETS



DRAINAGE LEGEND

- ECOLOGY EMBANKMENT
- —ST— PROPOSED CONVEYANCE
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING CULVERT
- EXISTING DITCH

MARCH 22, 2005

DRAFT RFP
CONCEPTUAL PLANS

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REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

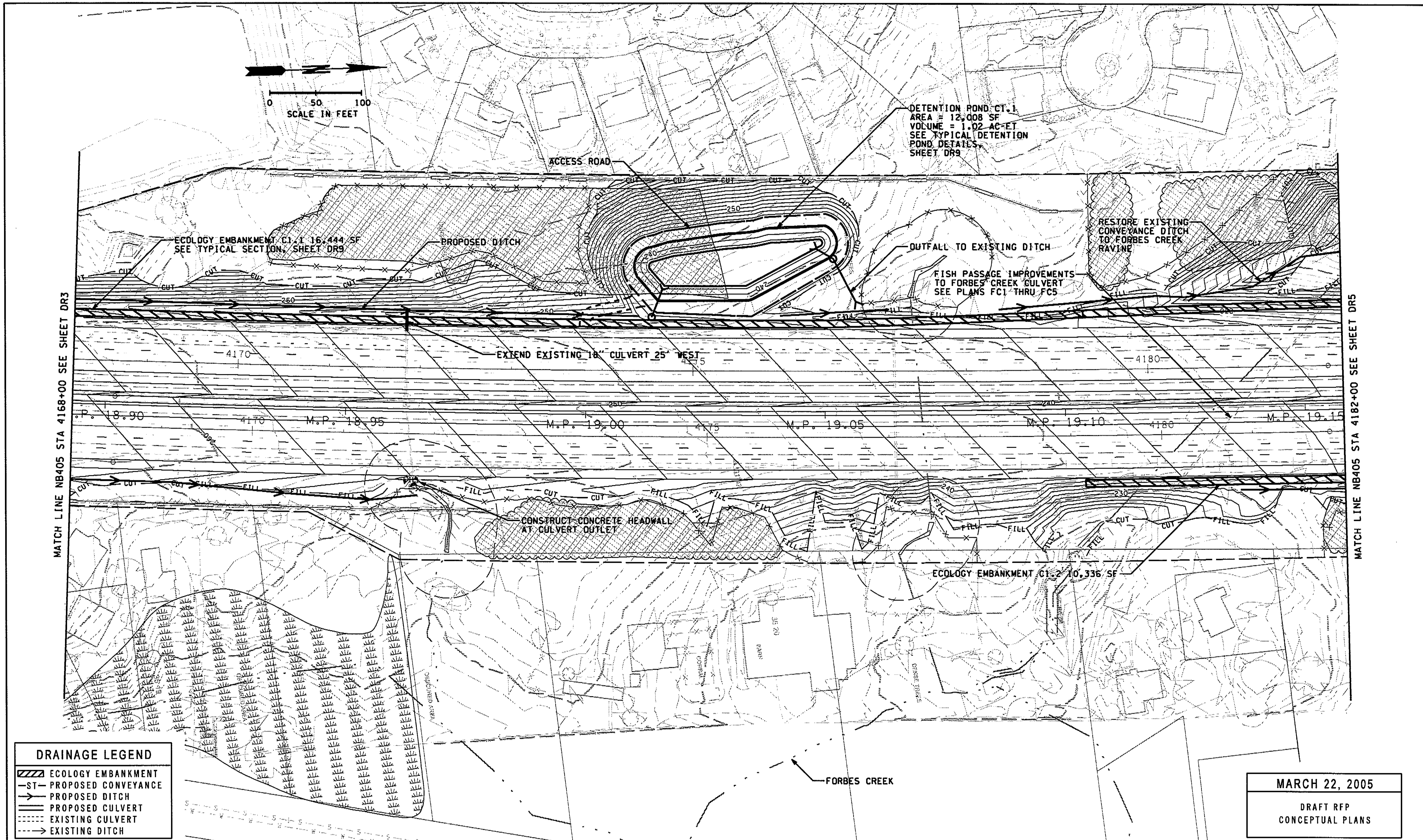
I-405
SR 520 TO SR 522

STAGE 1

DRAINAGE PLAN

DR3

SHEET OF SHEETS



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REGIONAL ADM.	D. DYE	REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

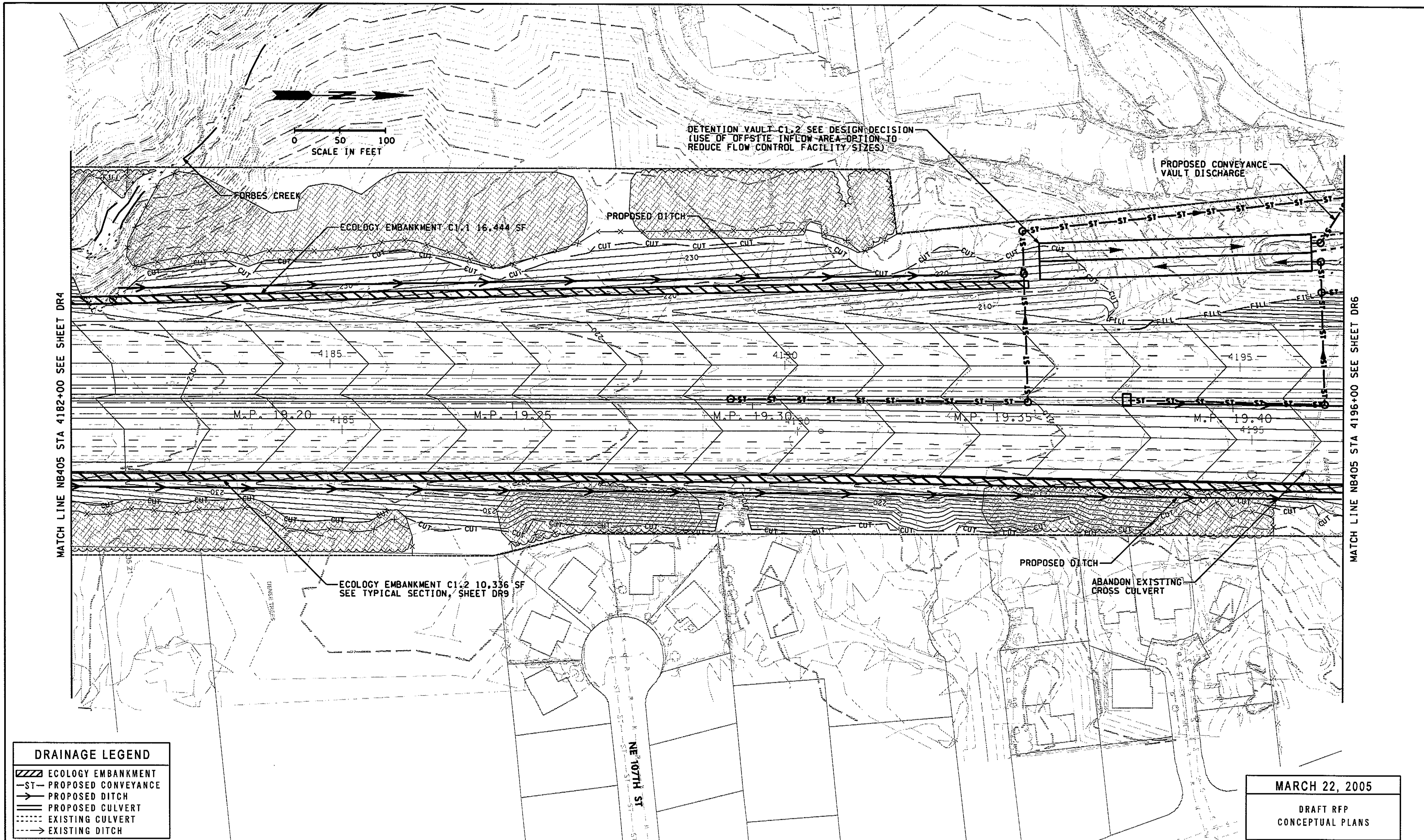
I-405
SR 520 TO SR 522

STAGE 1

DRAINAGE PLAN

DR4

SHEET OF SHEETS



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PROJ. ENGR. K. HENRY						
REGIONAL ADM. D. DYE	REVISION	DATE	BY			

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

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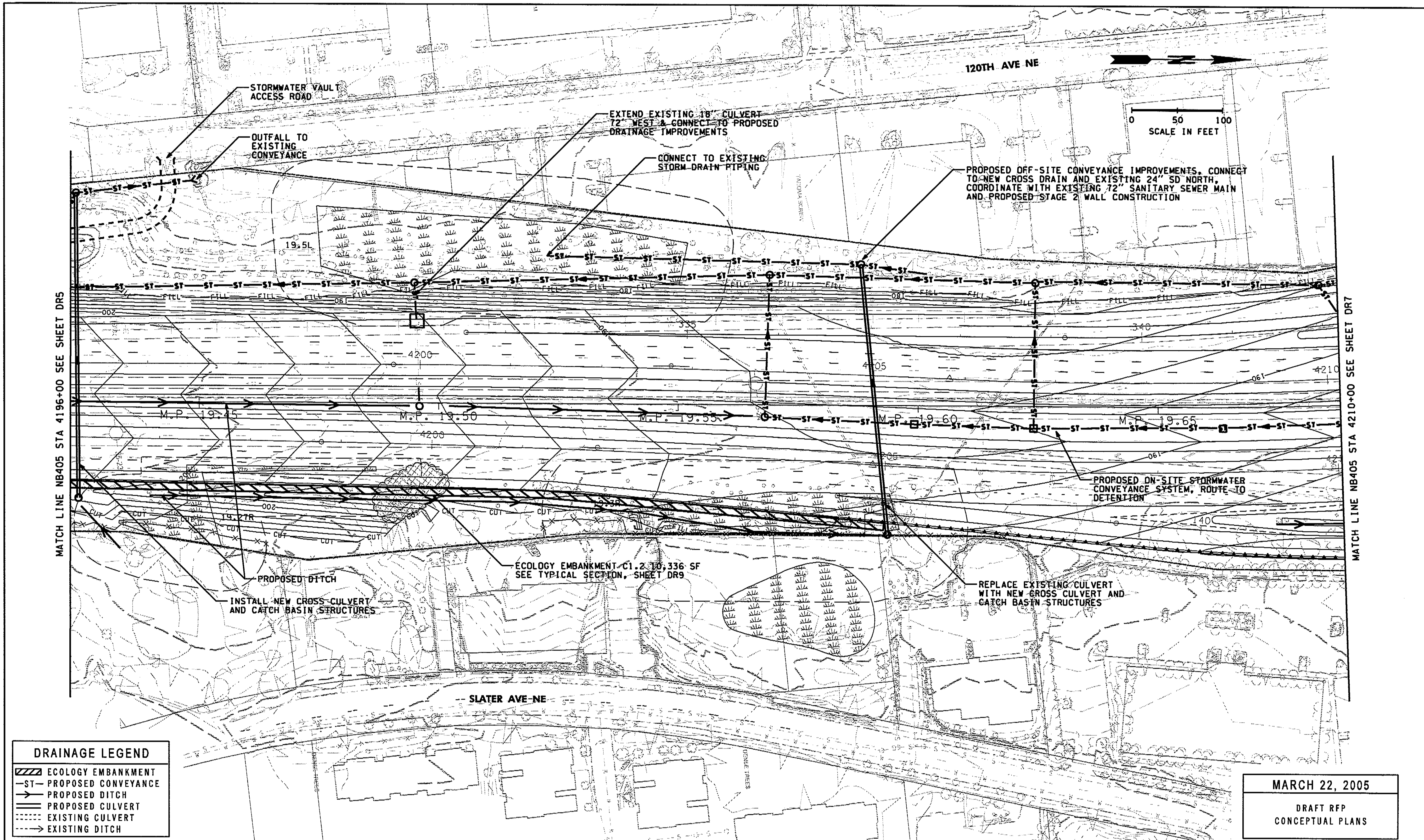
Washington State Department of Transportation

I-405
SR 520 TO SR 522
STAGE 1
DRAINAGE PLAN

DR5
SHEET OF SHEETS



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REGIONAL ADM.	D. DYE	REVISION	DATE / BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

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Washington State Department of Transportation

I-405
SR 520 TO SR 522
STAGE 1
DRAINAGE PLAN

DR6
SHEET OF SHEETS

DRAINAGE LEGEND

- ECOLOGY EMBANKMENT
- —ST— PROPOSED CONVEYANCE
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING CULVERT
- EXISTING DITCH

MARCH 22, 2005

DRAFT RFP
CONCEPTUAL PLANS

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REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

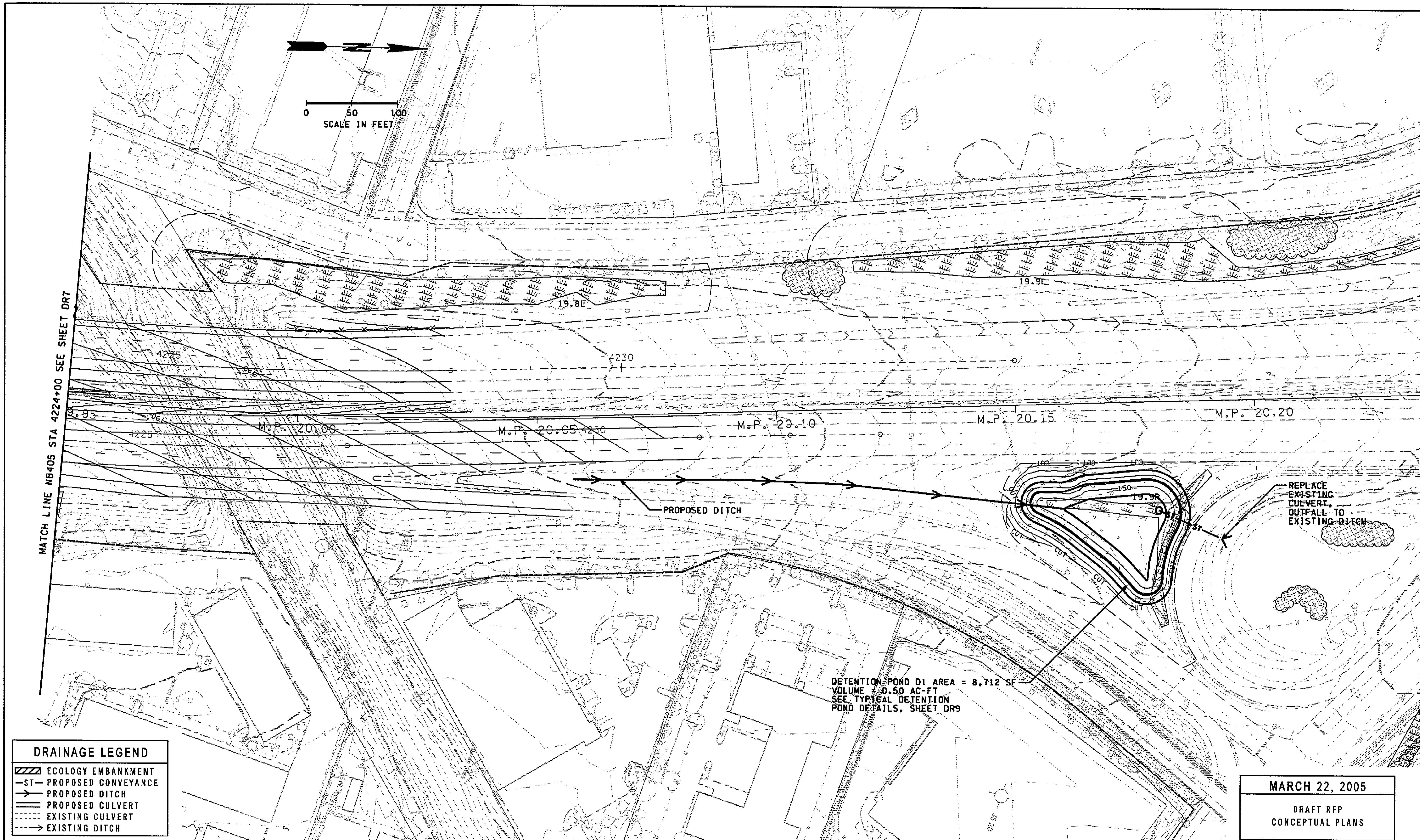
I-405
SR 520 TO SR 522

STAGE 1

DRAINAGE PLAN

DR7

SHEET OF SHEETS



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REGIONAL ADM.	D. DYE	REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

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Washington State Department of Transportation

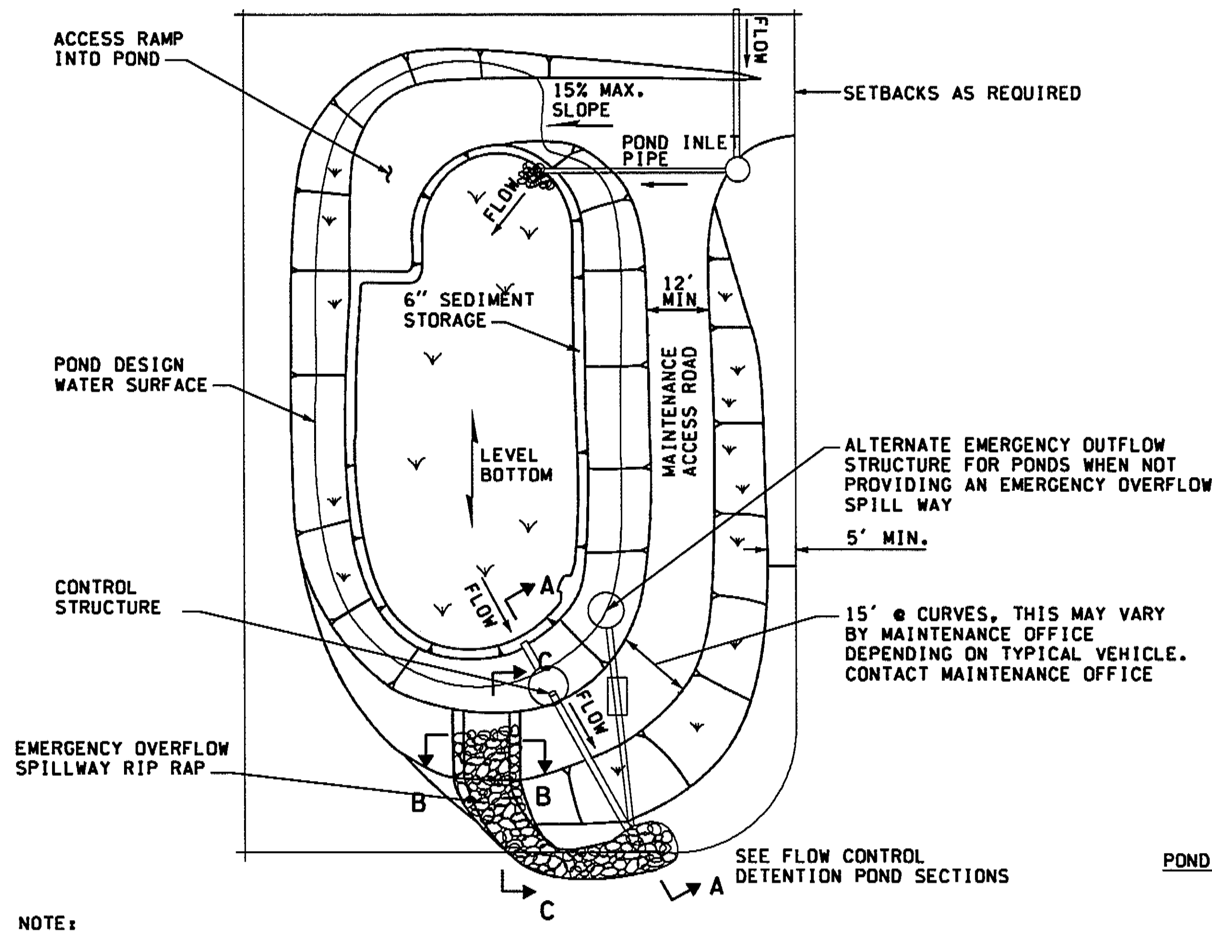
I-405
SR 520 TO SR 522

STAGE 1

DRAINAGE PLAN

DR8

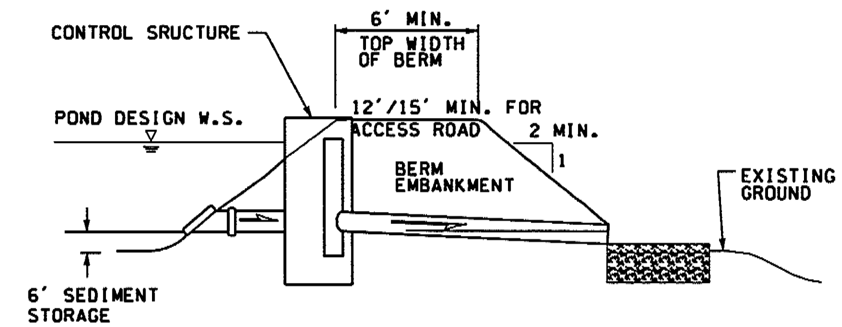
SHEET OF SHEETS



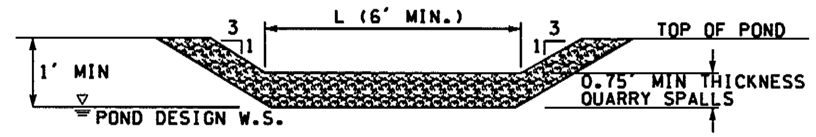
NOTE:
THIS DETAIL IS A SCHEMATIC REPRESENTATION ONLY. ACTUAL CONFIGUATION WILL VARY DEPENDING ON SPECIFIC SITE CONSTRAINTS AND APPLICABLE DESIGN CRITERIA.

FLOW CONTROL DETENTION POND PLAN

N.T.S.

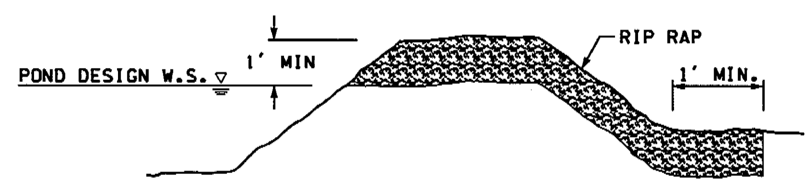


SECTION A-A



NOTES:
1. LENGTH OF SPILLWAY (L) IS SIZED BASED ON 100 YEAR POST DEVELOPED PEAK FLOW SEE TEXT FOR EQUATIONS.
2. SEE WSDOT HYDRAULICS MANUAL FOR RIP RAP SIZING CRITERIA

SECTION B-B
EMERGENCY OVERFLOW SPILLWAY

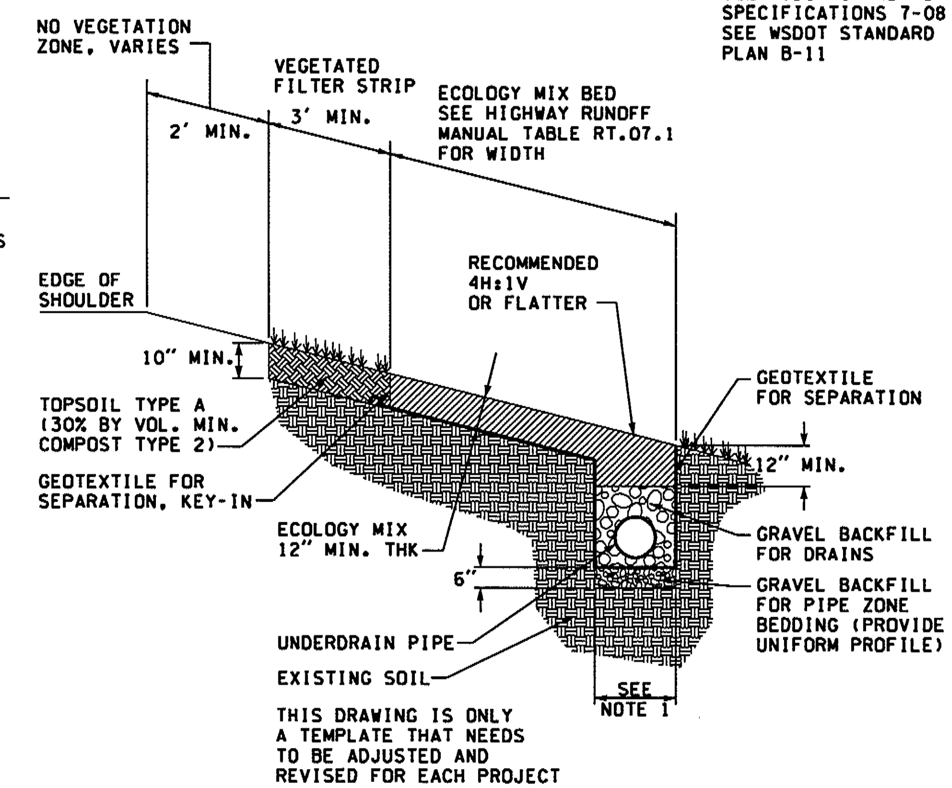


SECTION C-C

FLOW CONTROL DETENTION POND SECTION

N.T.S.

NOTE:
1. SEE WSDOT STANDARD SPECIFICATIONS 7-08 SEE WSDOT STANDARD PLAN B-11



THIS DRAWING IS ONLY A TEMPLATE THAT NEEDS TO BE ADJUSTED AND REVISED FOR EACH PROJECT

ECOLOGY EMBANKMENT

SIDE SLOPE APPLICATION WITH UNDERDRAIN
N.T.S.

MARCH 22, 2005
DRAFT RFP
CONCEPTUAL PLANS

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PROJ. ENGR.	K. HENRY		
REGIONAL ADM.	D. DYE	REVISION	DATE / BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.
JOB NUMBER
CONTRACT NO. | LOCATION NO.

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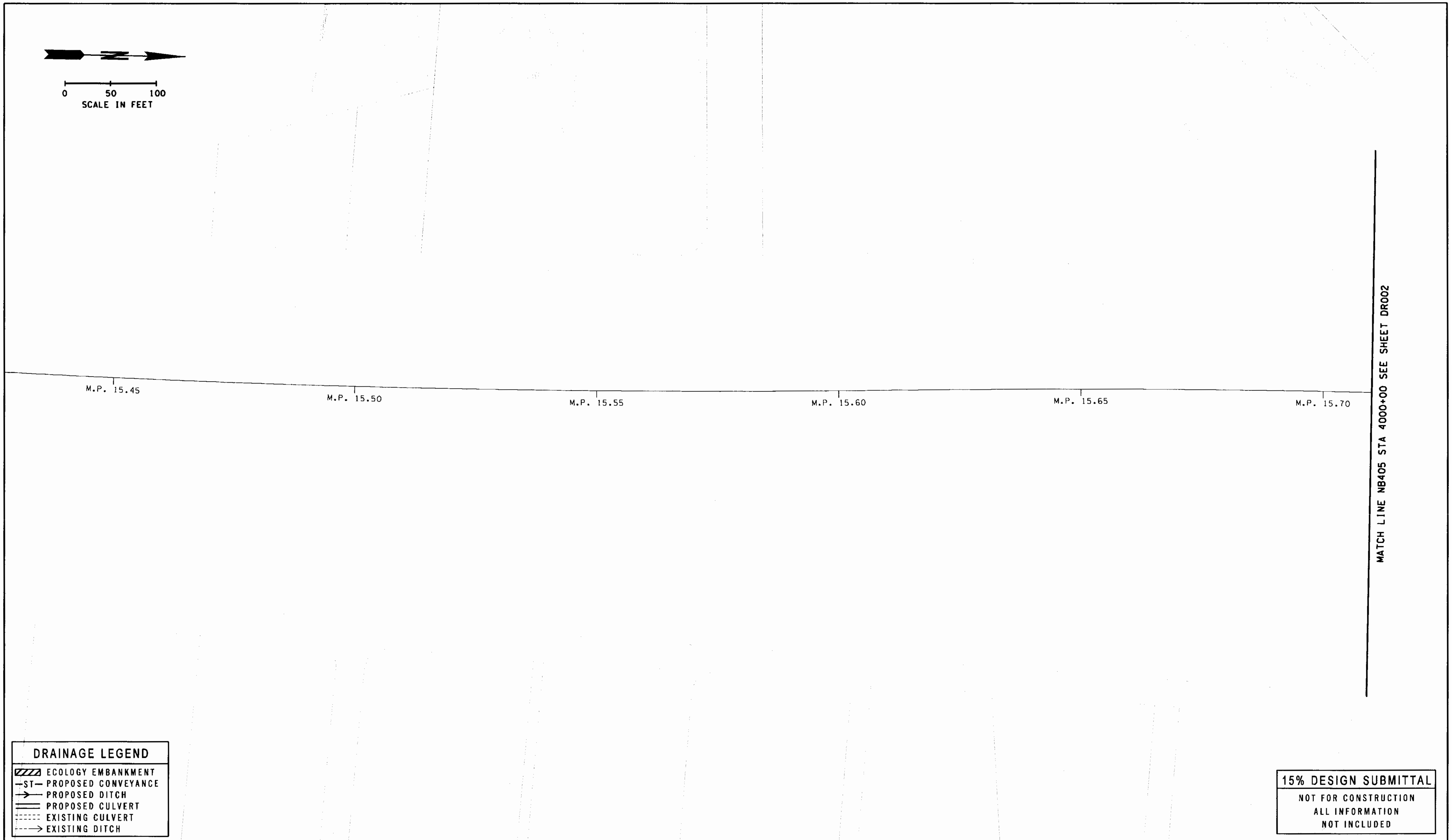
Washington State Department of Transportation

I-405
SR 520 TO SR 522
STAGE 1
DRAINAGE DETAIL

DR9
SHEET OF SHEETS

STAGE 2 DRAINAGE PLANS



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REGIONAL ADM.

REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	

JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX — DATE

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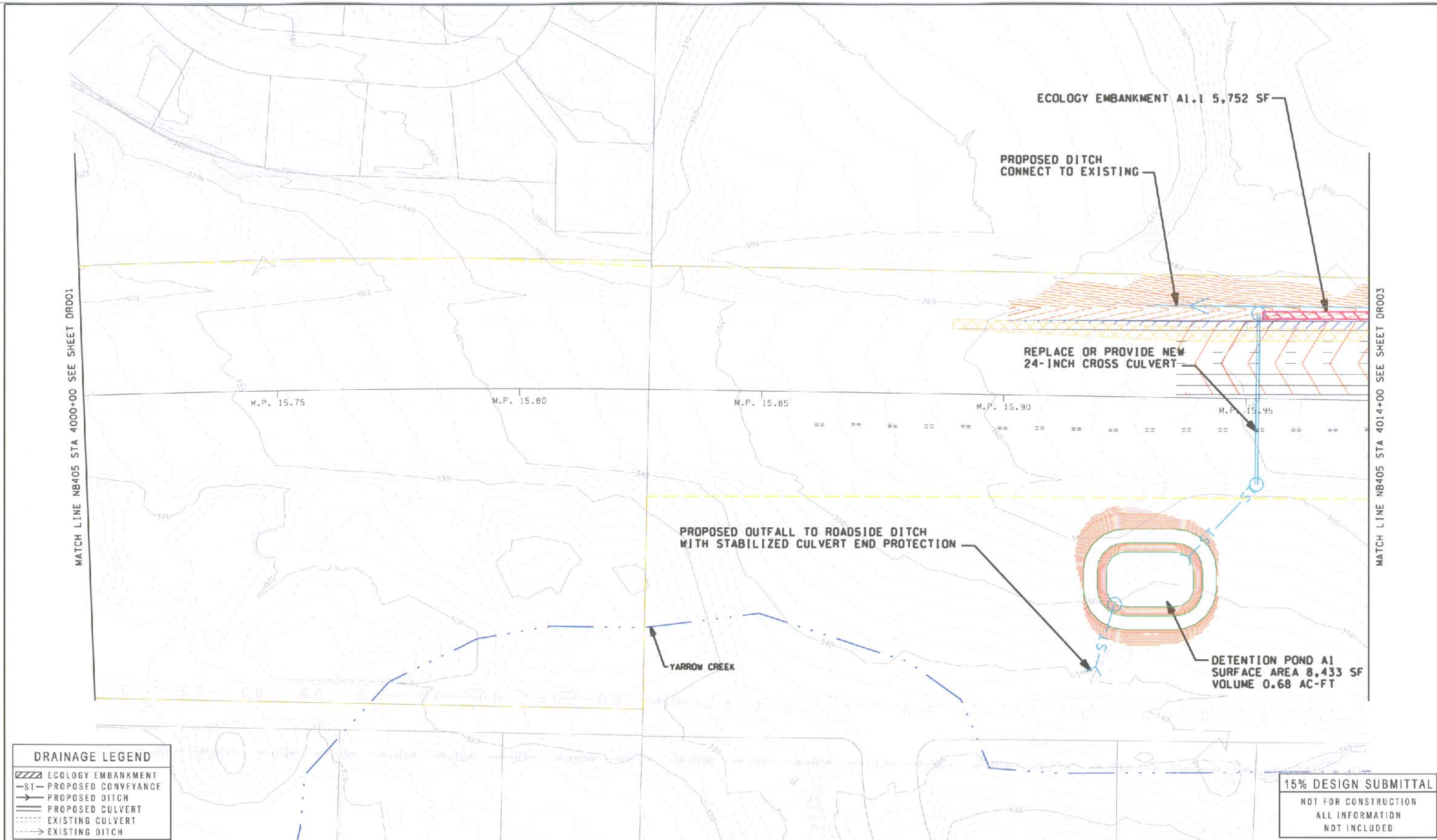
I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR001

SHEET 1 OF 35 SHEETS



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REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
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CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

Washington State Department of Transportation

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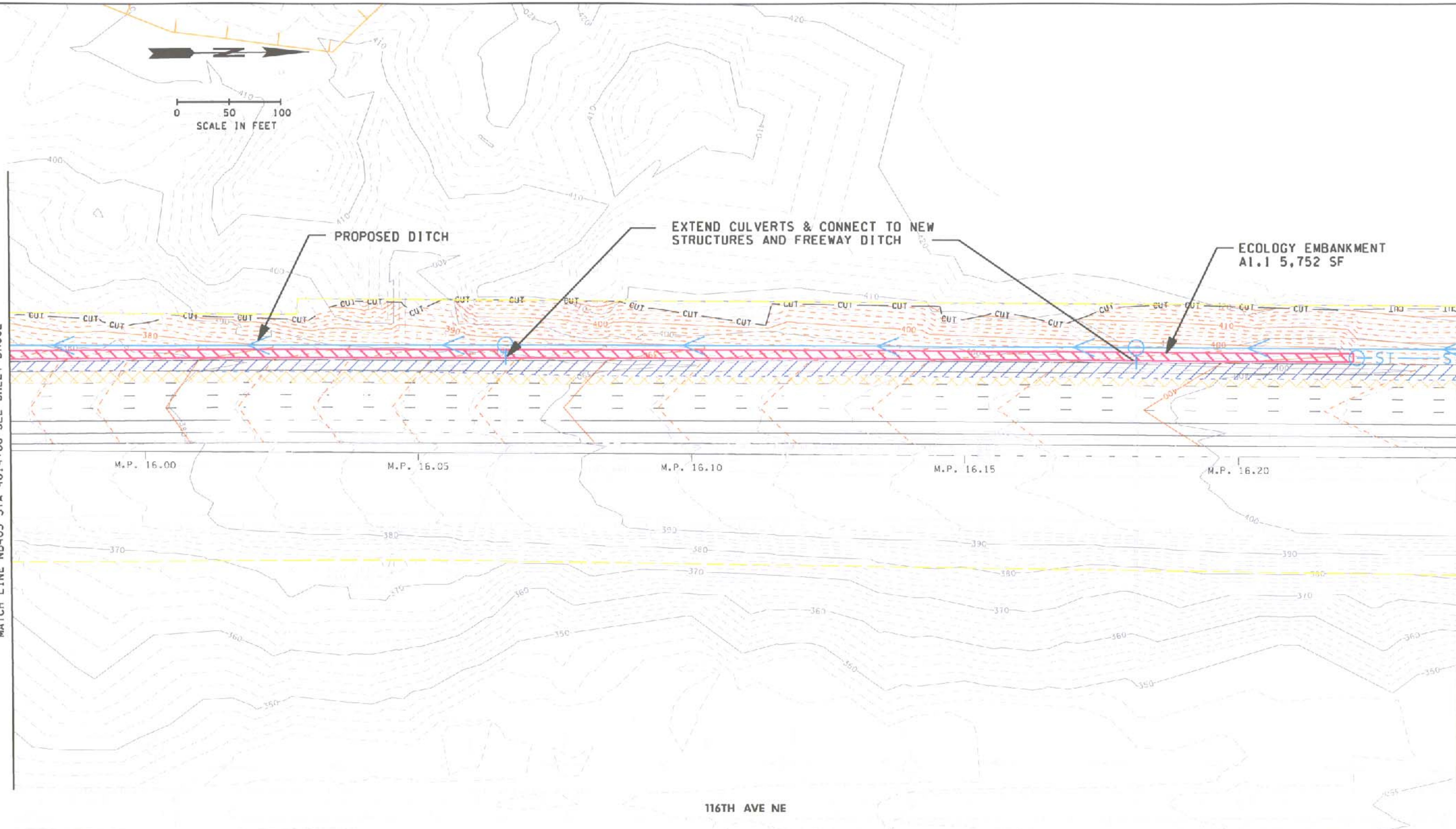
KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR002

SHEET 2 OF 35 SHEETS



DRAINAGE LEGEND

- ECOLOGY EMBANKMENT
- —ST— PROPOSED CONVEYANCE
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING CULVERT
- EXISTING DITCH

15% DESIGN SUBMITTAL

NOT FOR CONSTRUCTION
ALL INFORMATION
NOT INCLUDED

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10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

DATE
P.E. STAMP BOX

DATE
P.E. STAMP BOX

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Washington State Department of Transportation

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KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR003

SHEET 3 OF 35 SHEETS

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PROJ. ENGR.
REGIONAL ADM.

REVISION	DATE	BY

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10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

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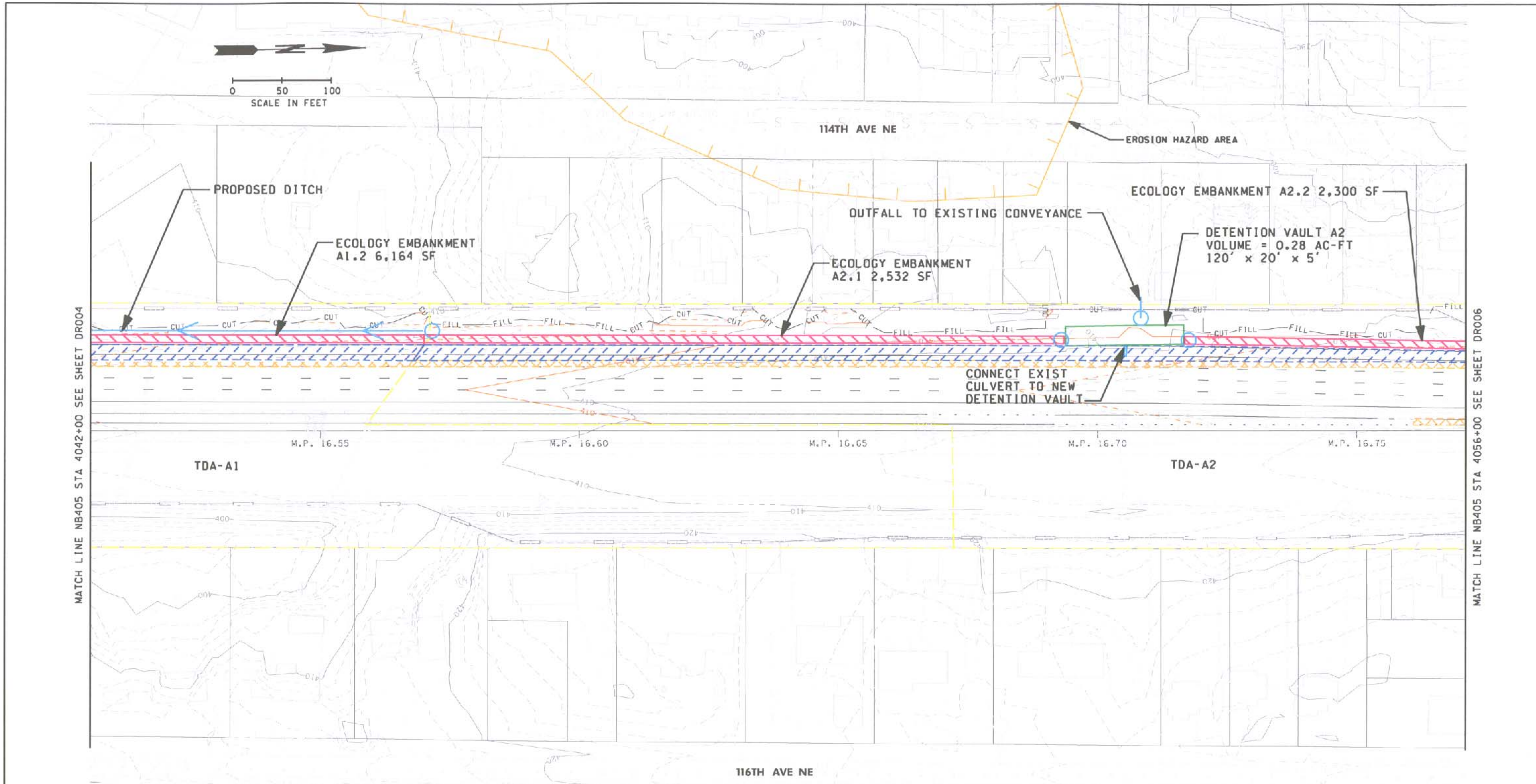
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR004

SHEET 4 OF 35 SHEETS



DRAINAGE LEGEND

▨▨▨	ECOLOGY EMBANKMENT
—ST—	PROPOSED CONVEYANCE
——→	PROPOSED DITCH
═══	PROPOSED CULVERT
------	EXISTING CULVERT
----→	EXISTING DITCH

15% DESIGN SUBMITTAL

NOT FOR CONSTRUCTION
ALL INFORMATION
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REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

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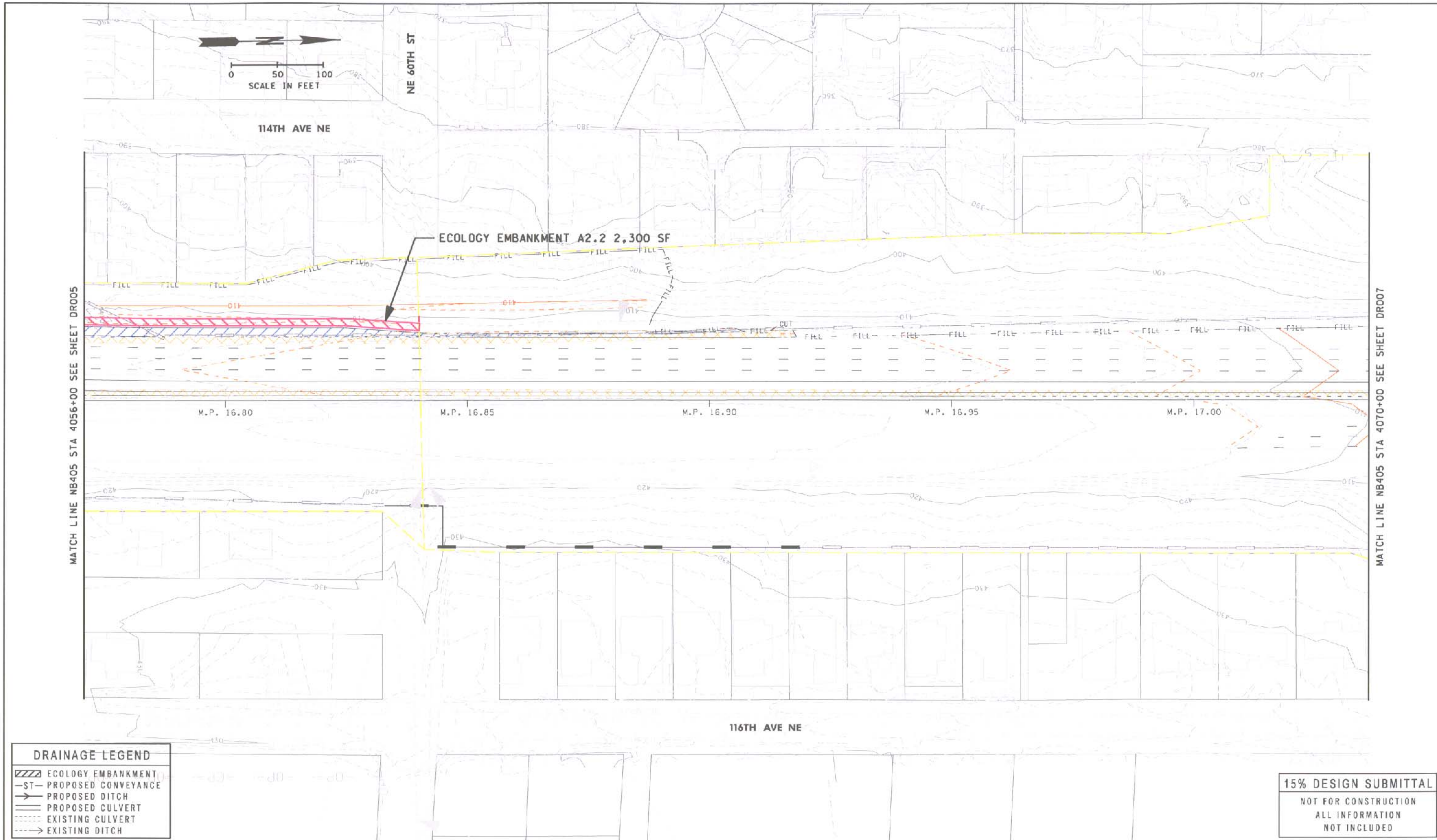
I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR005

SHEET 5 OF 35 SHEETS



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REGIONAL ADM.	REVISION	DATE	BY		

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

DATE
P.E. STAMP BOX

DATE
P.E. STAMP BOX

INTERSTATE 405 Project Team
Washington State Department of Transportation

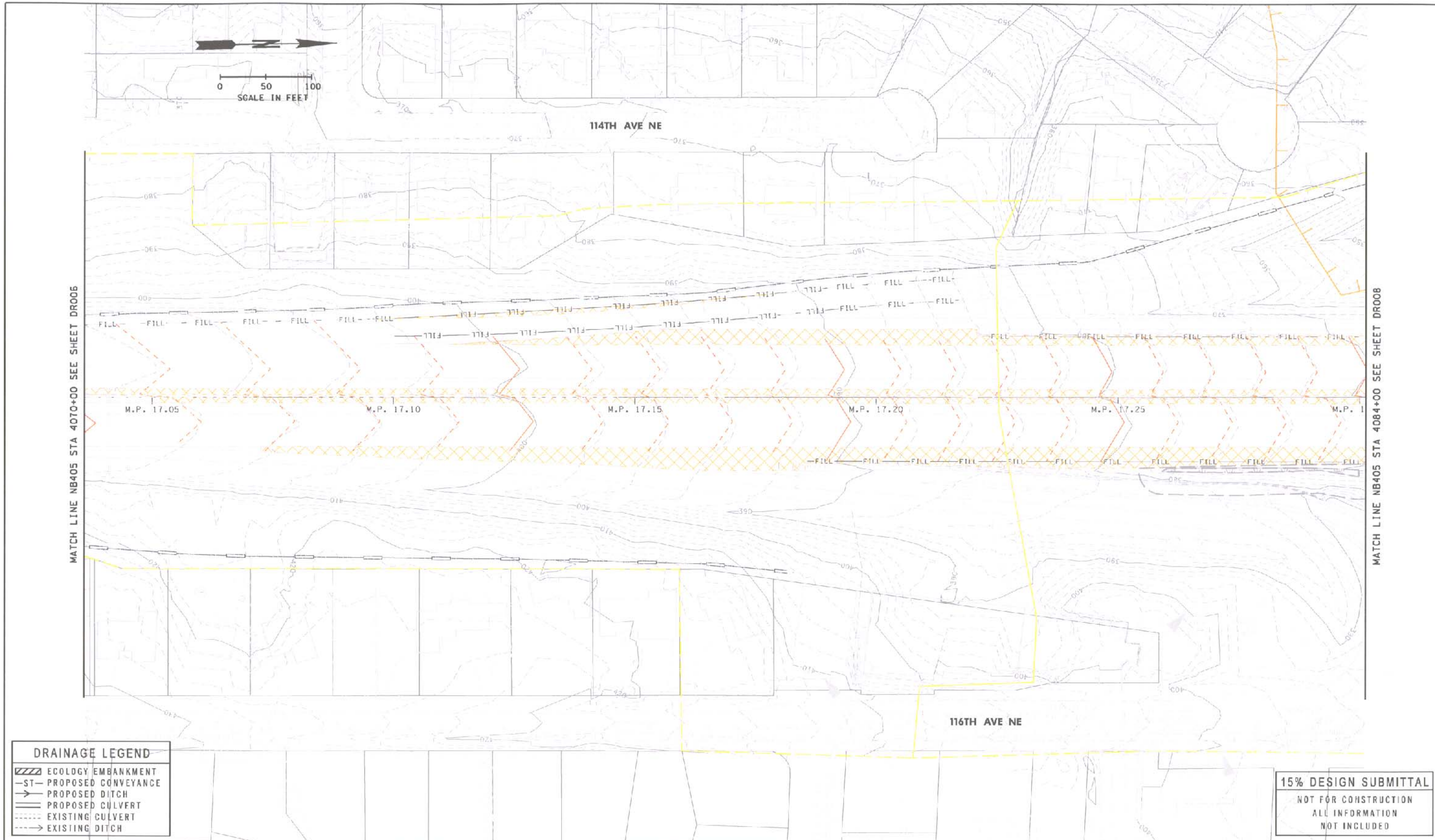
I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR006

SHEET 6 OF 35 SHEETS



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REGION NO.	STATE	FED.AID PROJ.NO.
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P.E. STAMP BOX DATE

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Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR007

SHEET 7 OF 35 SHEETS

DRAINAGE LEGEND

- ECOLOGY EMBANKMENT
- —ST— PROPOSED CONVEYANCE
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING CULVERT
- EXISTING DITCH

15% DESIGN SUBMITTAL

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ALL INFORMATION
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REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team

Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR008

SHEET 8 OF 35 SHEETS

DRAINAGE LEGEND

- ECOLOGY EMBANKMENT
- —ST— PROPOSED CONVEYANCE
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING CULVERT
- EXISTING DITCH

15% DESIGN SUBMITTAL

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REGION NO.	STATE	FED.AID PROJ.NO.
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P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team

Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR009

SHEET 9 OF 35 SHEETS

FILE NAME
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JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

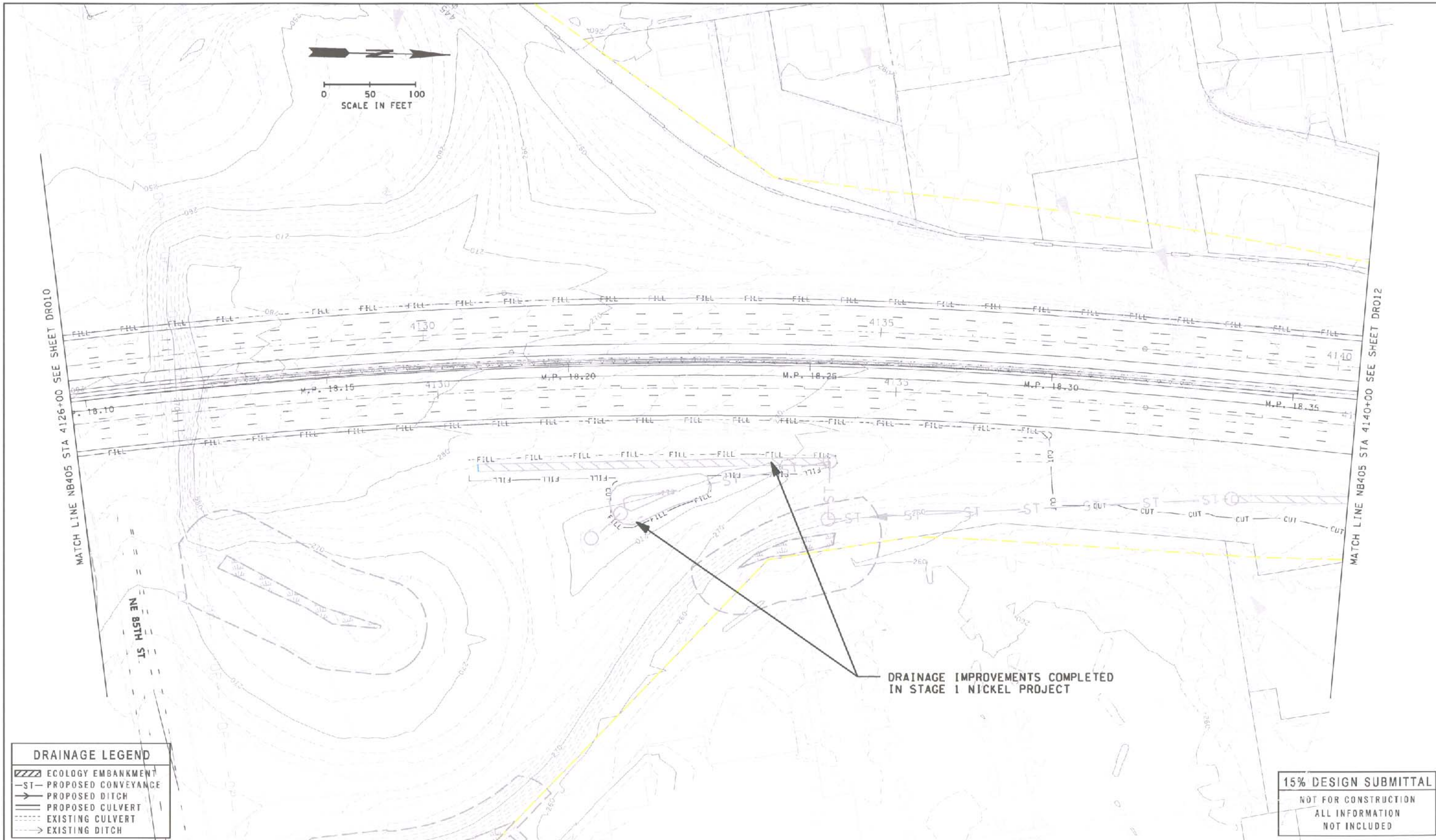
I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR010

SHEET 10 OF 35 SHEETS



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P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team

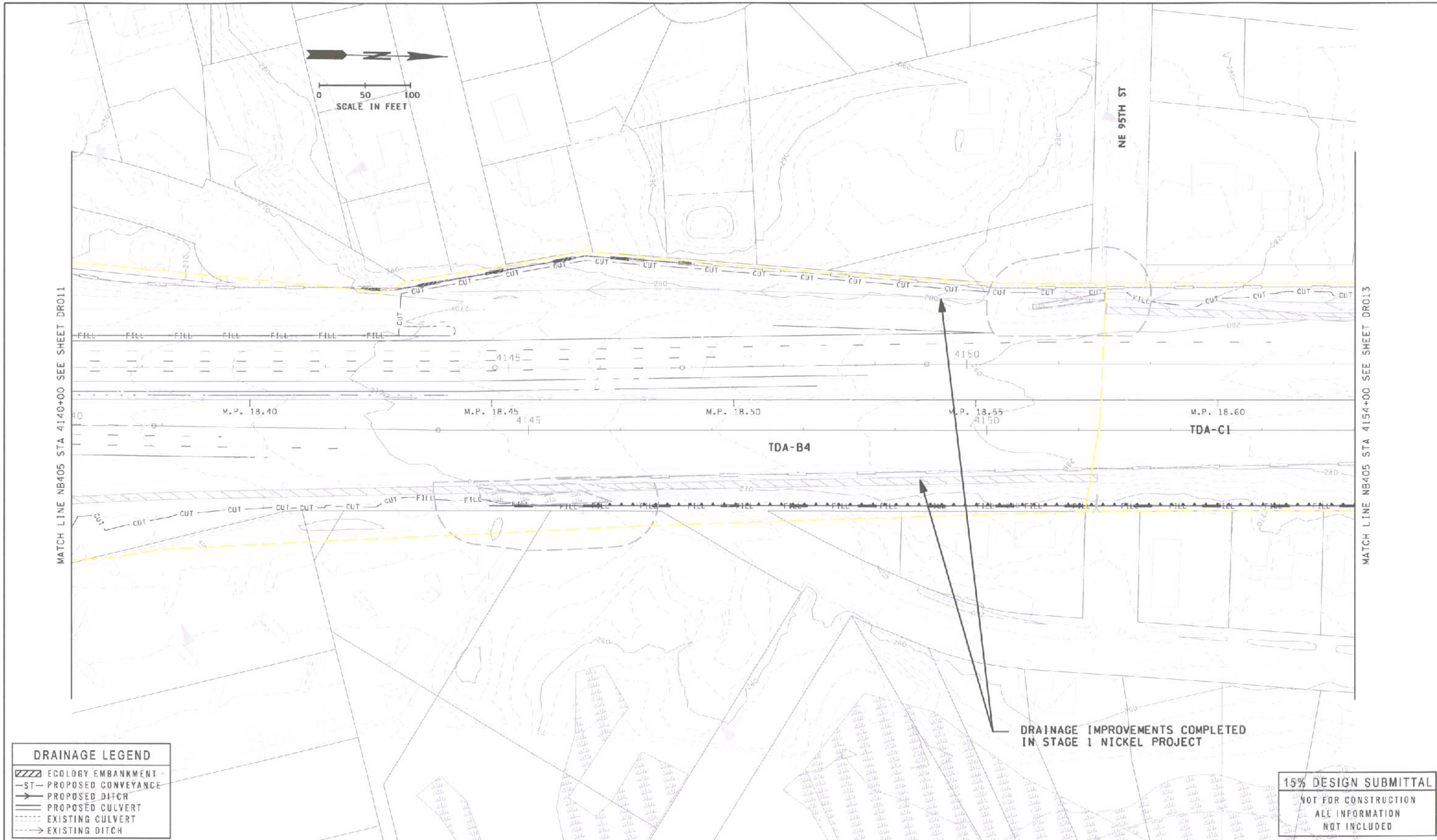
Washington State Department of Transportation

I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR011

SHEET 11 OF 35 SHEETS



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REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

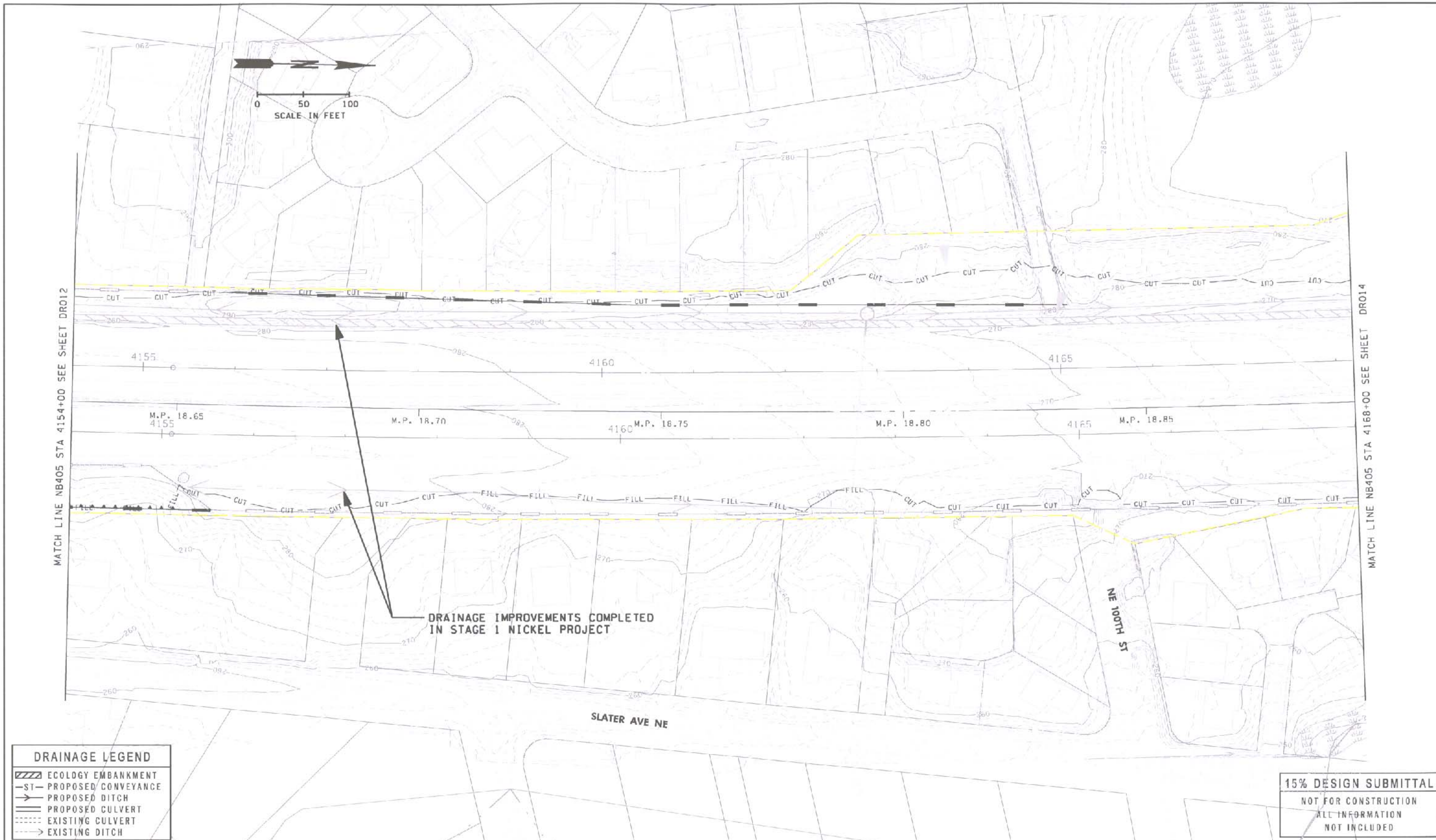
INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR012

SHEET 12 OF 35 SHEETS



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REGIONAL ADM.

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CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE
P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR013

SHEET 13 OF 35 SHEETS

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JOB NUMBER
CONTRACT NO. | LOCATION NO.

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P.E. STAMP BOX DATE

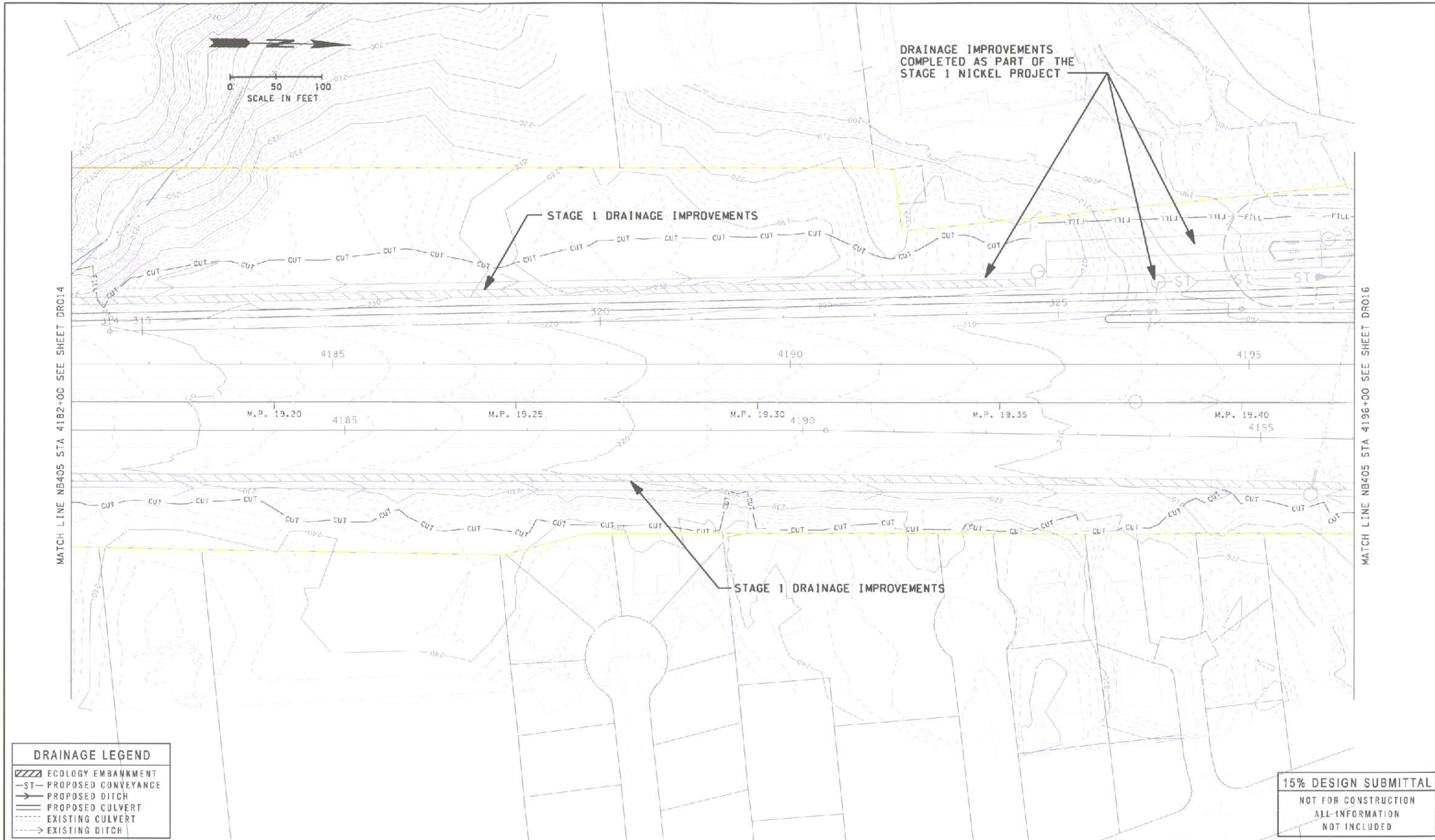
INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR014

SHEET 14 OF 35 SHEETS



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JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

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INTERSTATE 405 Project Team

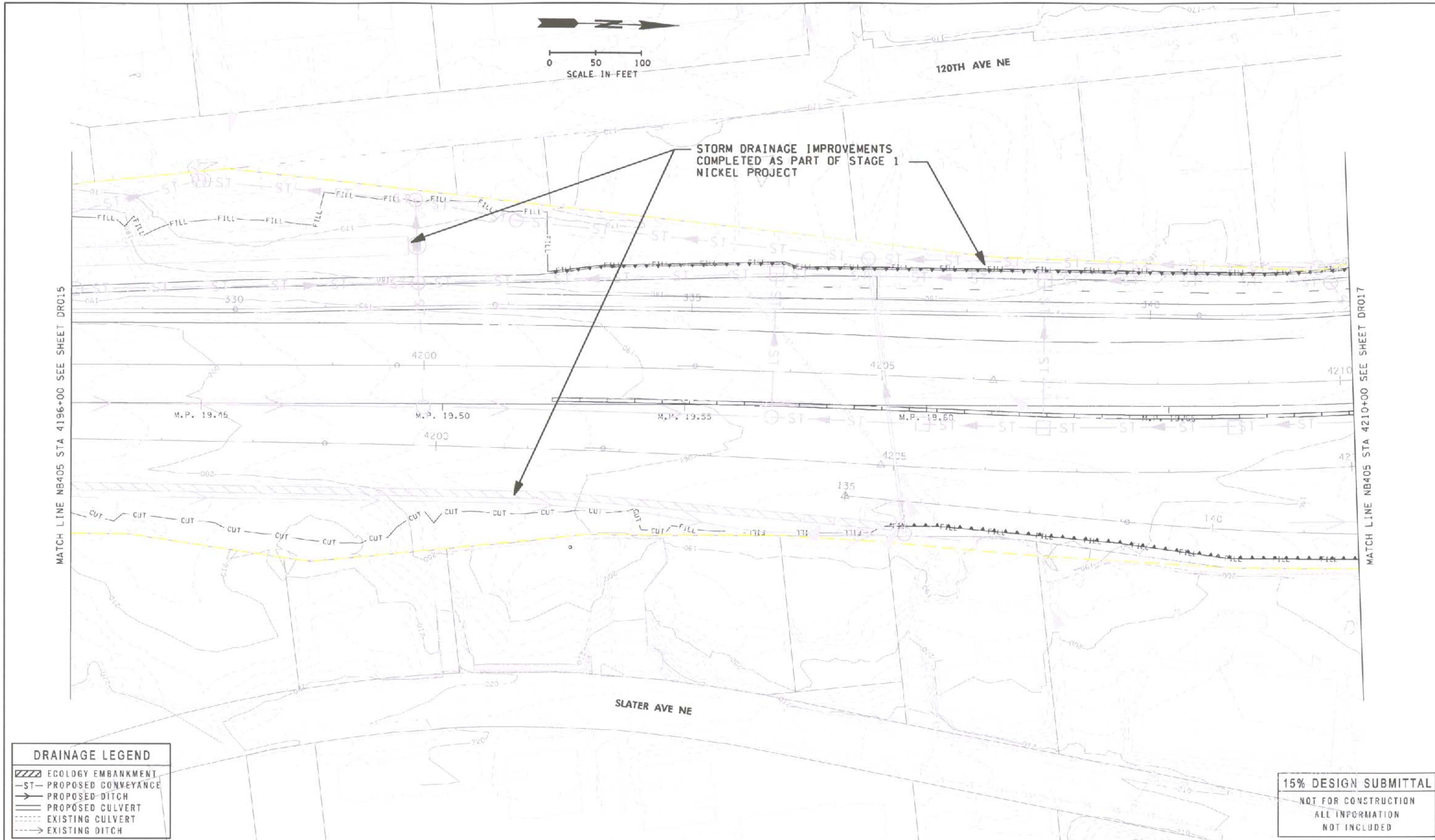
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR015

SHEET 15 OF 35 SHEETS



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REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	

JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE

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INTERSTATE 405 Project Team

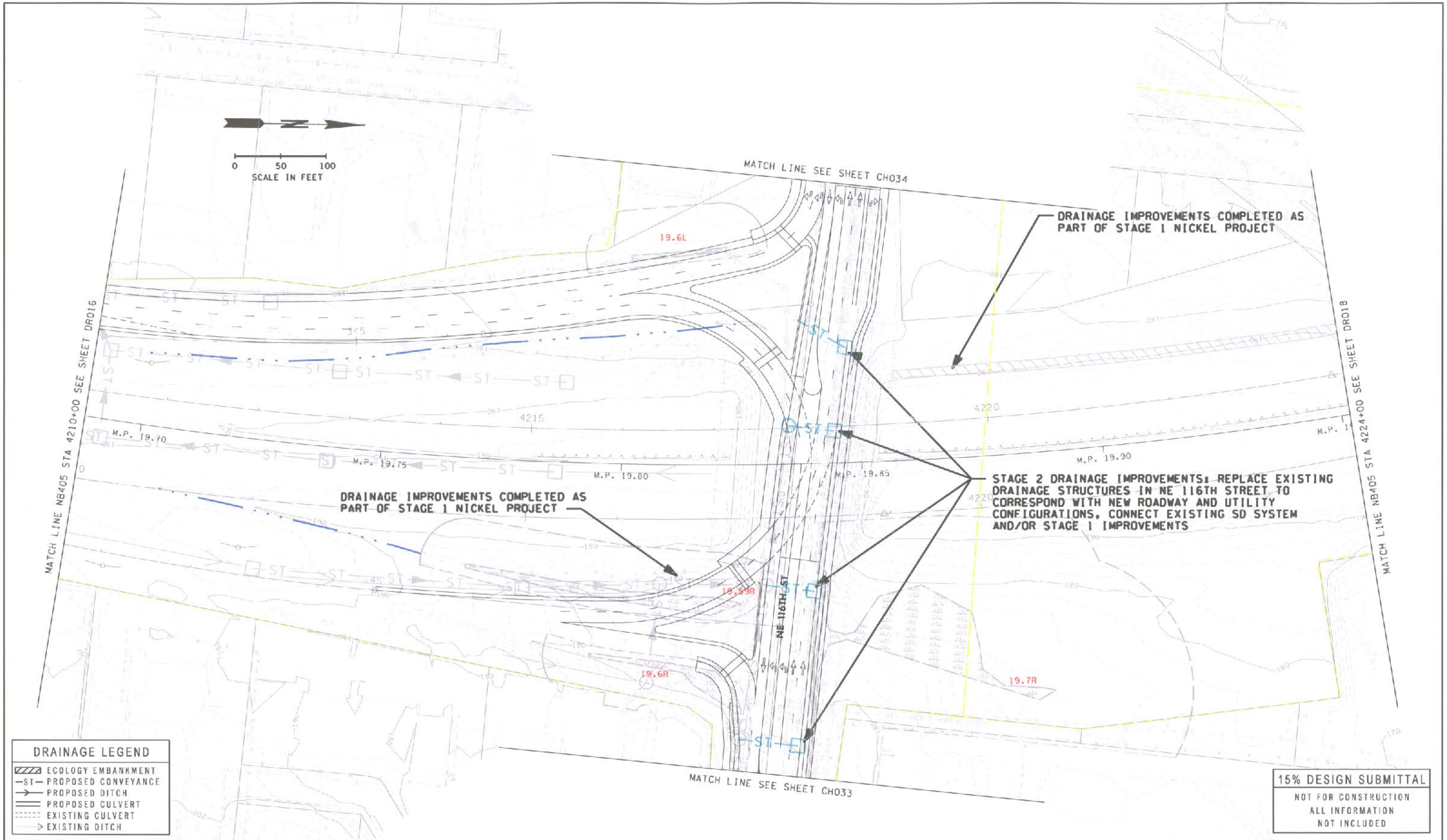
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR016

SHEET 16 OF 35 SHEETS



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REGION NO.	STATE	FED.AID PROJ.NO.
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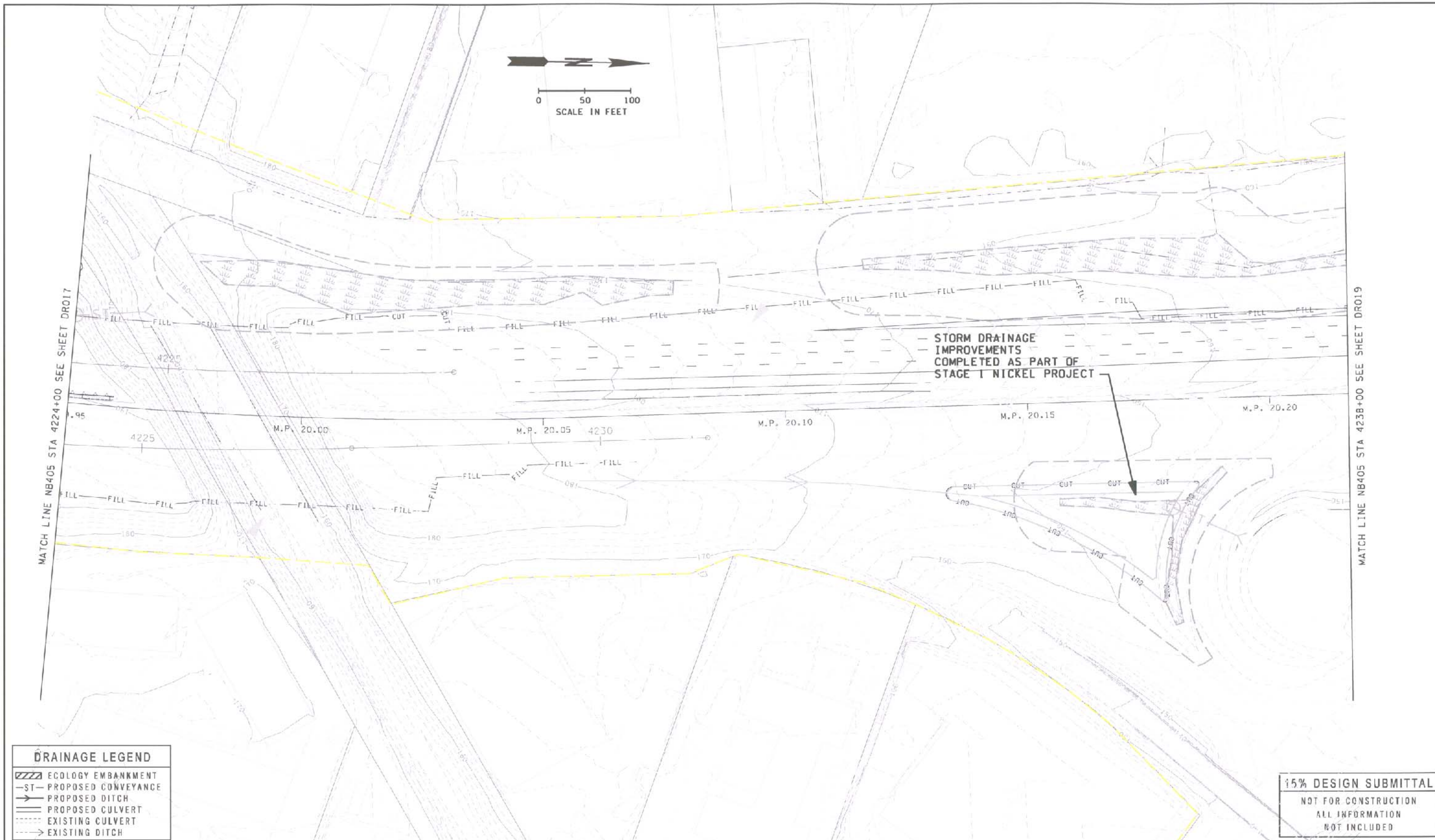
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR017

SHEET 17 OF 35 SHEETS



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JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

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Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR018

SHEET 18 OF 35 SHEETS

DRAINAGE LEGEND

- ECOLOGY EMBANKMENT
- —ST— PROPOSED CONVEYANCE
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING CULVERT
- EXISTING DITCH

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Washington State Department of Transportation

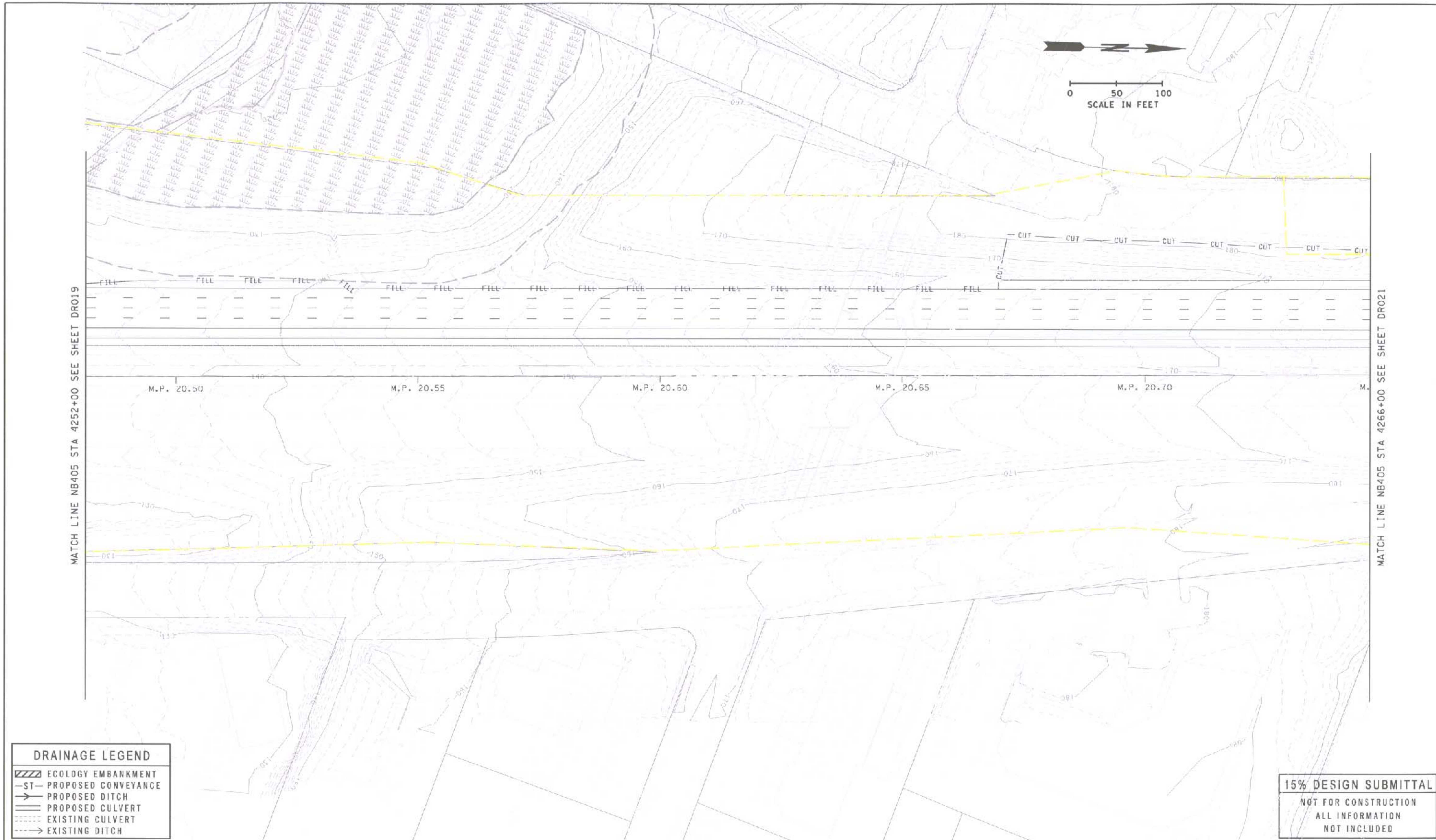
I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR019

SHEET 19 OF 35 SHEETS



DRAINAGE LEGEND

- ECOLOGY EMBANKMENT
- —ST— PROPOSED CONVEYANCE
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING CULVERT
- EXISTING DITCH

15% DESIGN SUBMITTAL

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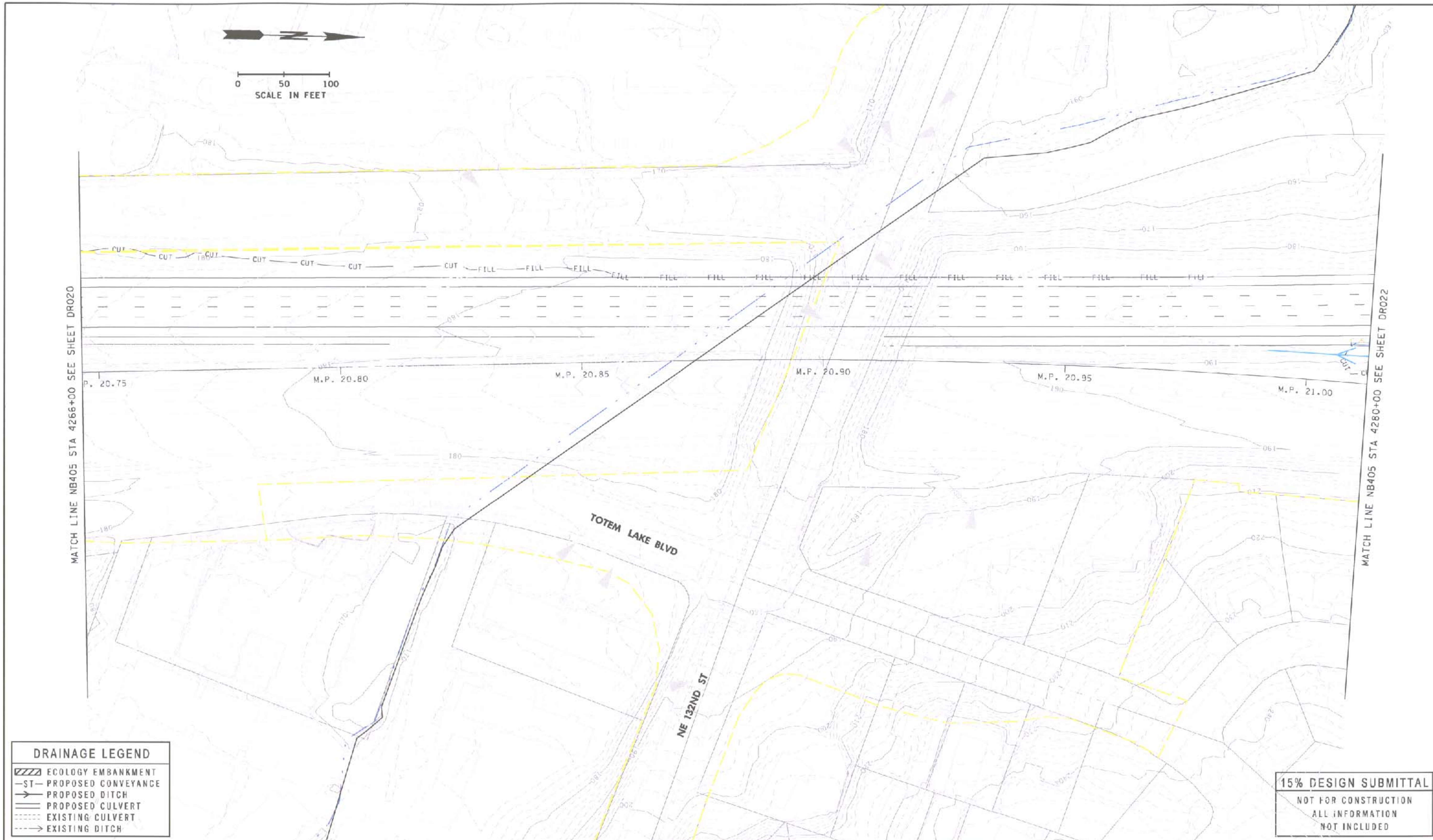
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR020

SHEET 20 OF 35 SHEETS



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CONTRACT NO.		LOCATION NO.

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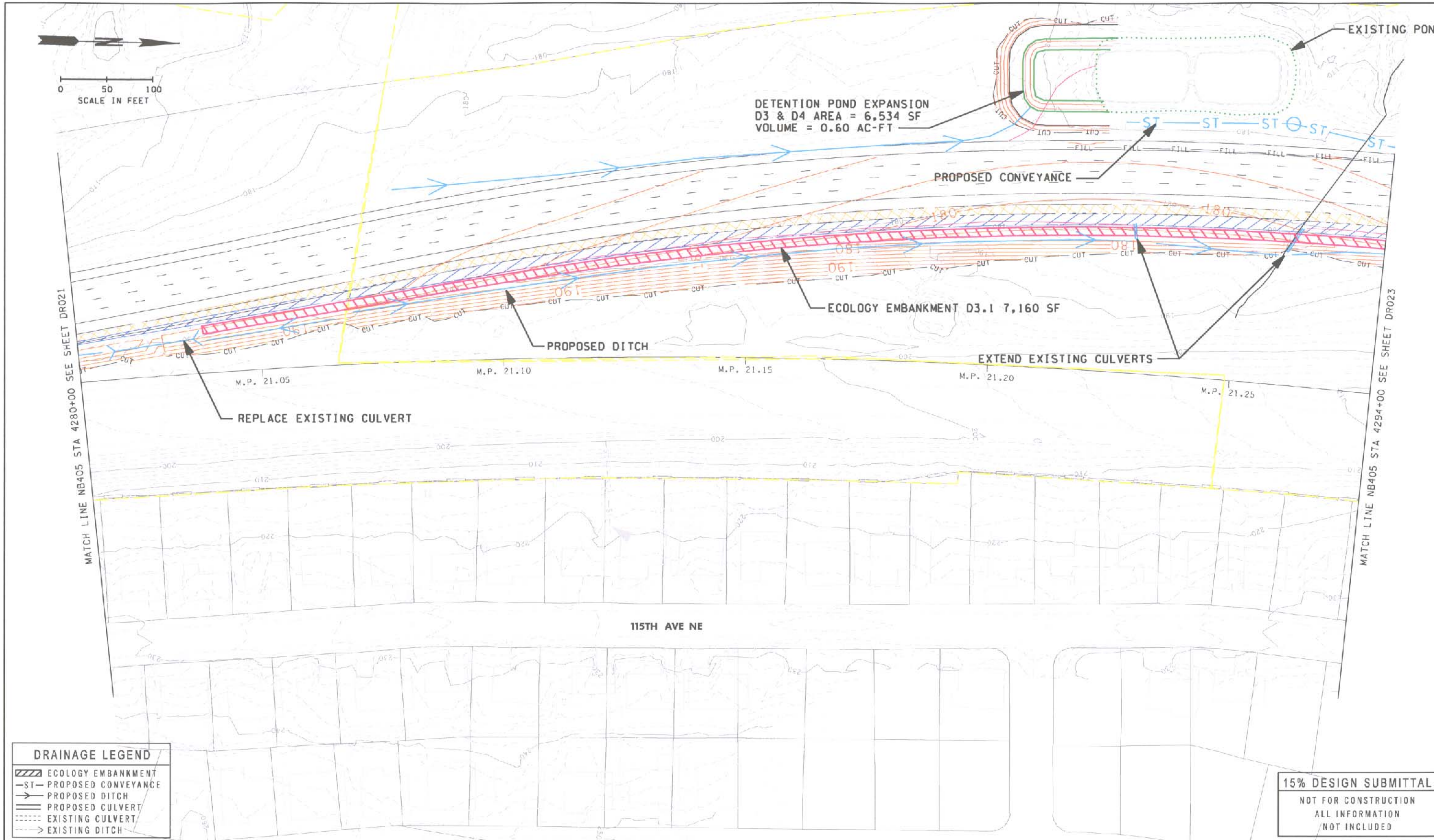
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR021

SHEET 21 OF 35 SHEETS



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REGION NO.	STATE	FED.AID PROJ.NO.
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JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

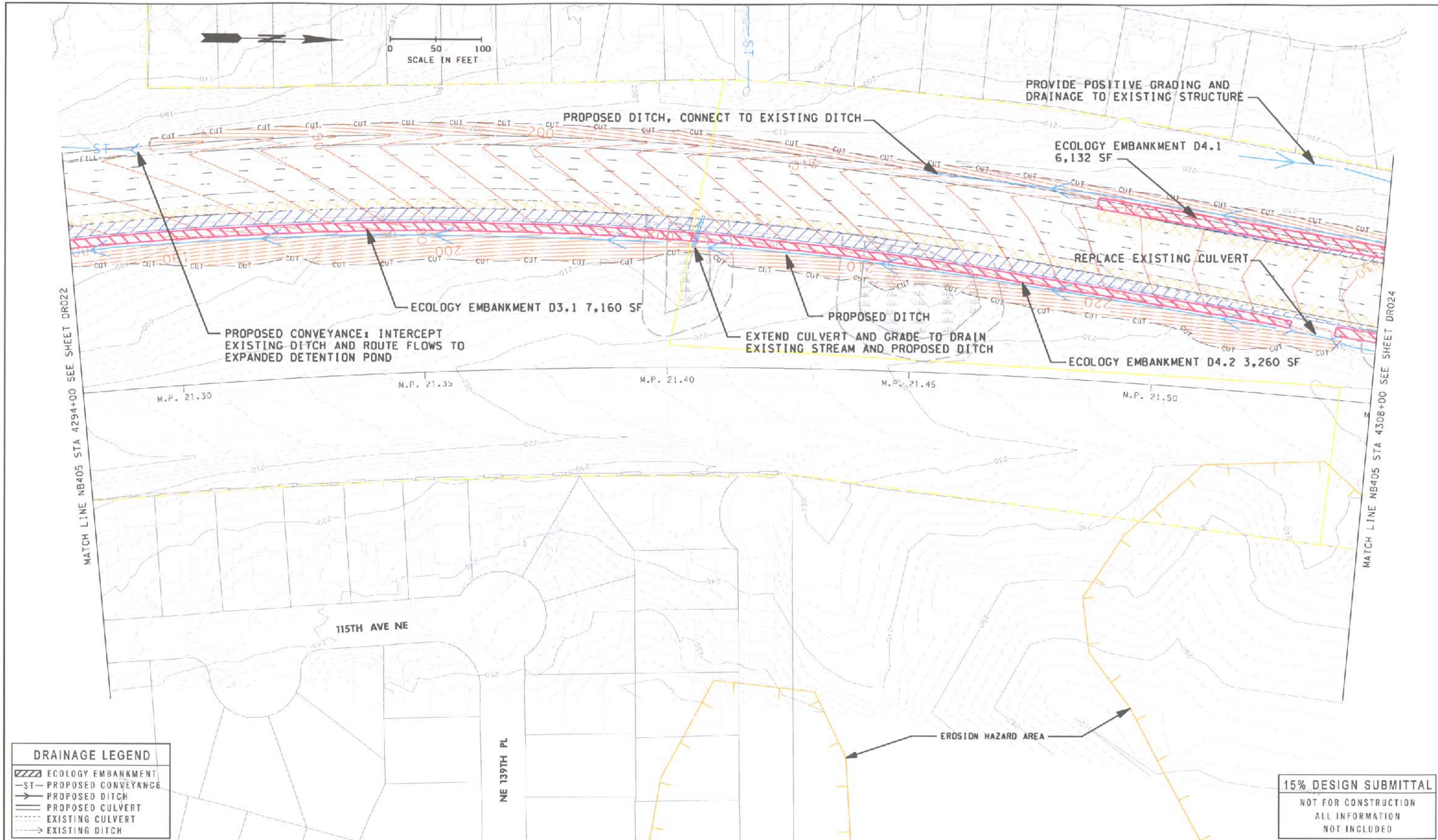
INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR022

SHEET 22 OF 35 SHEETS



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REGION NO.	STATE	FED.AID PROJ.NO.
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CONTRACT NO.		LOCATION NO.

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INTERSTATE 405 Project Team

Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR023

SHEET 23 OF 35 SHEETS

DRAINAGE LEGEND

- ECOLOGY EMBANKMENT
- —ST— PROPOSED CONVEYANCE
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING CULVERT
- EXISTING DITCH

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REGION NO.	STATE	FED.AID PROJ.NO.
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DATE
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DATE
P.E. STAMP BOX

INTERSTATE 405 Project Team
Washington State Department of Transportation

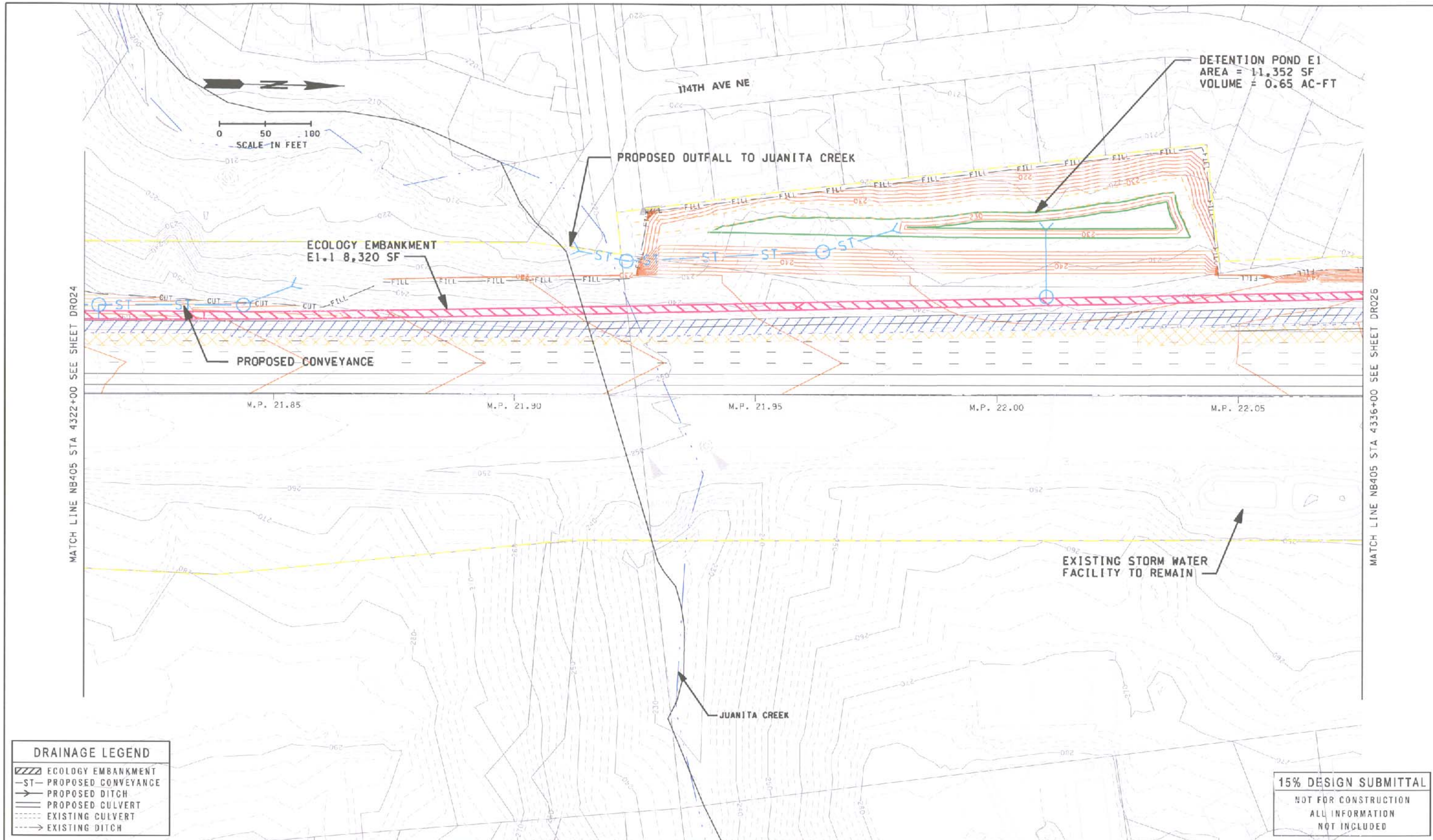
I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR024

SHEET 24 OF 35 SHEETS



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REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER

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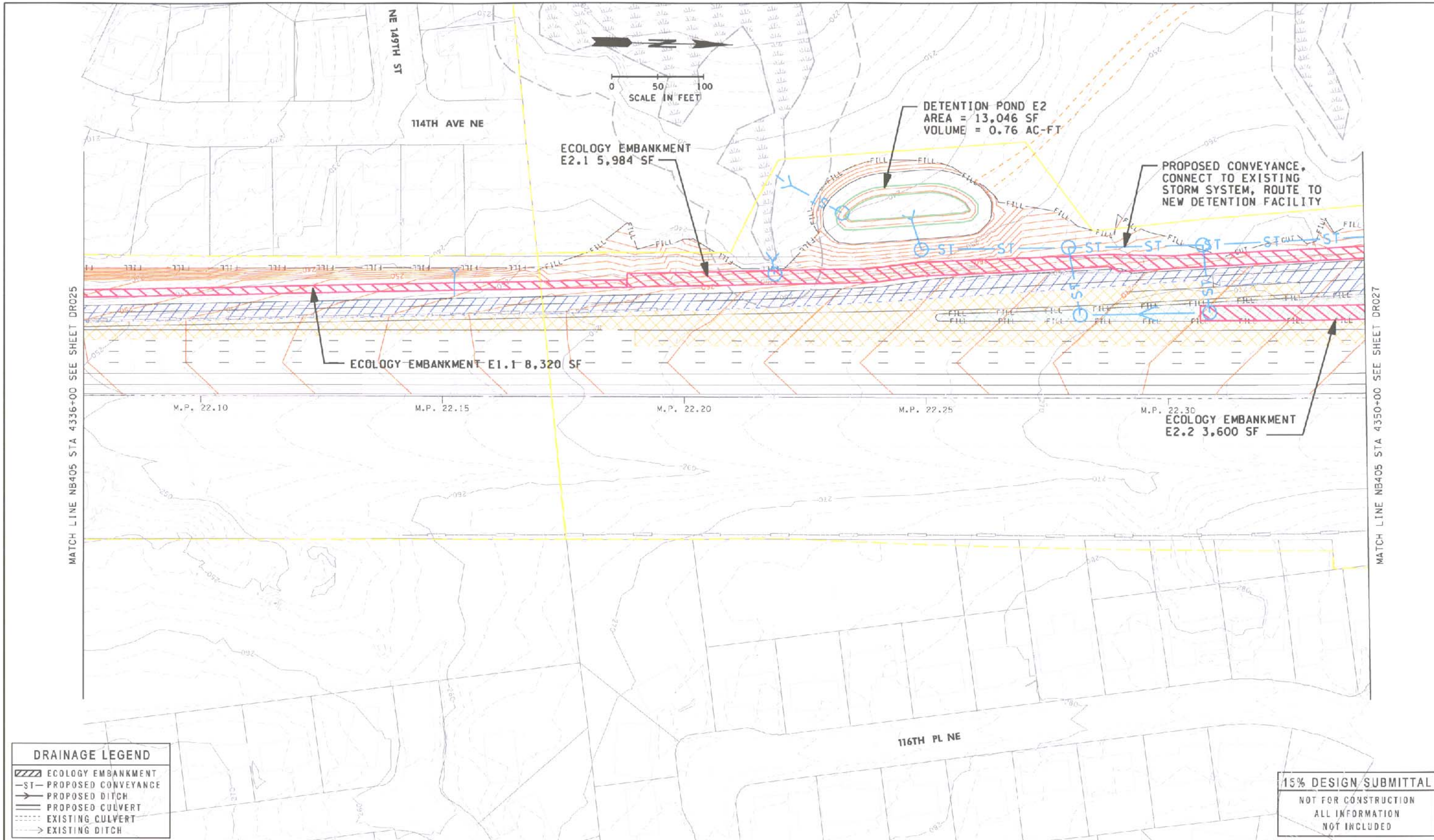
Washington State Department of Transportation

I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR025

SHEET 25 OF 35 SHEETS



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INTERSTATE 405 Project Team

Washington State Department of Transportation

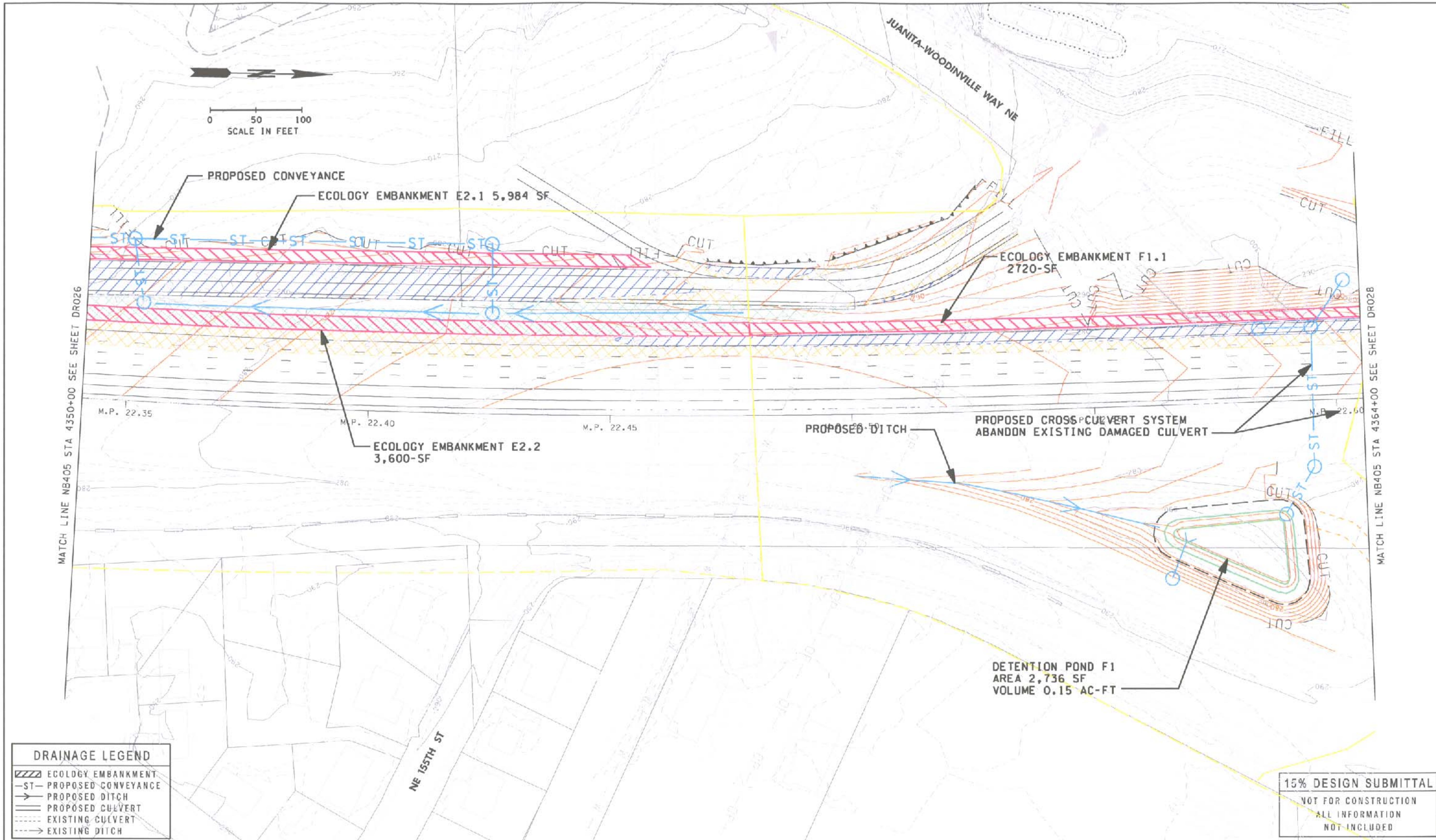
I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR026

SHEET 26 OF 35 SHEETS



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P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team

Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR027

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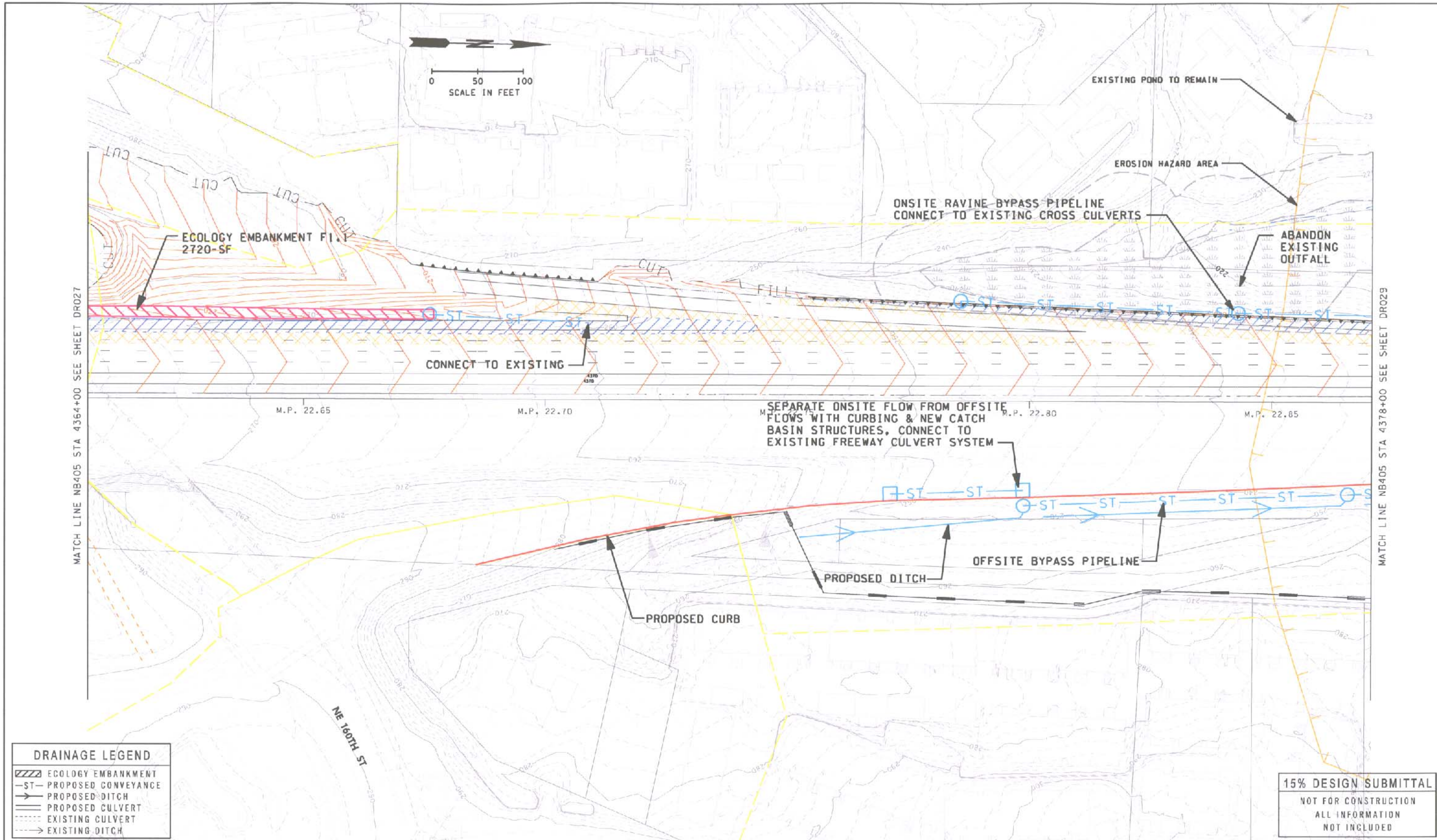

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CONTRACT NO. | LOCATION NO.

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P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

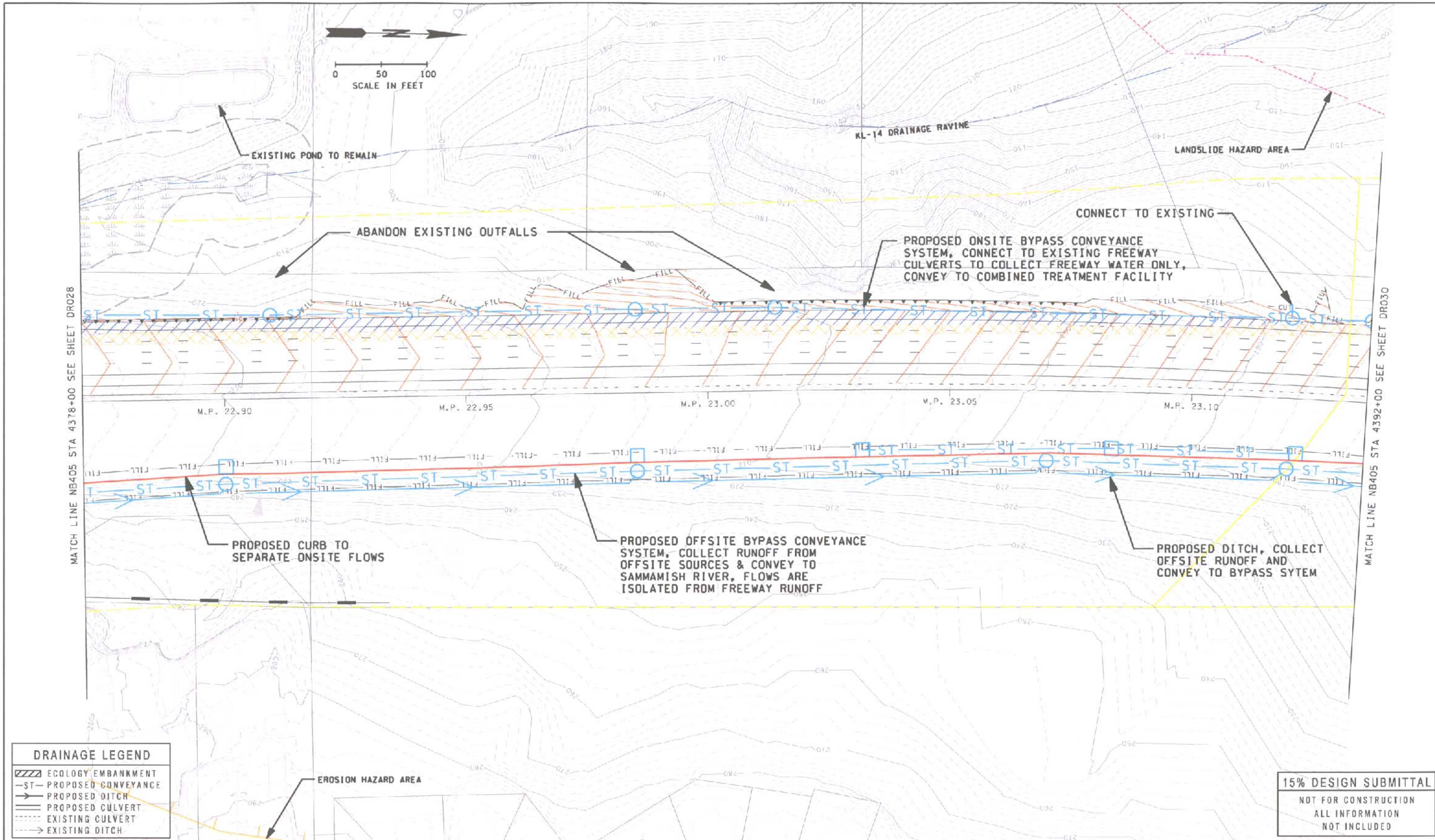
I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR028

SHEET 28 OF 35 SHEETS



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P.E. STAMP BOX DATE

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INTERSTATE 405 Project Team

Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR029

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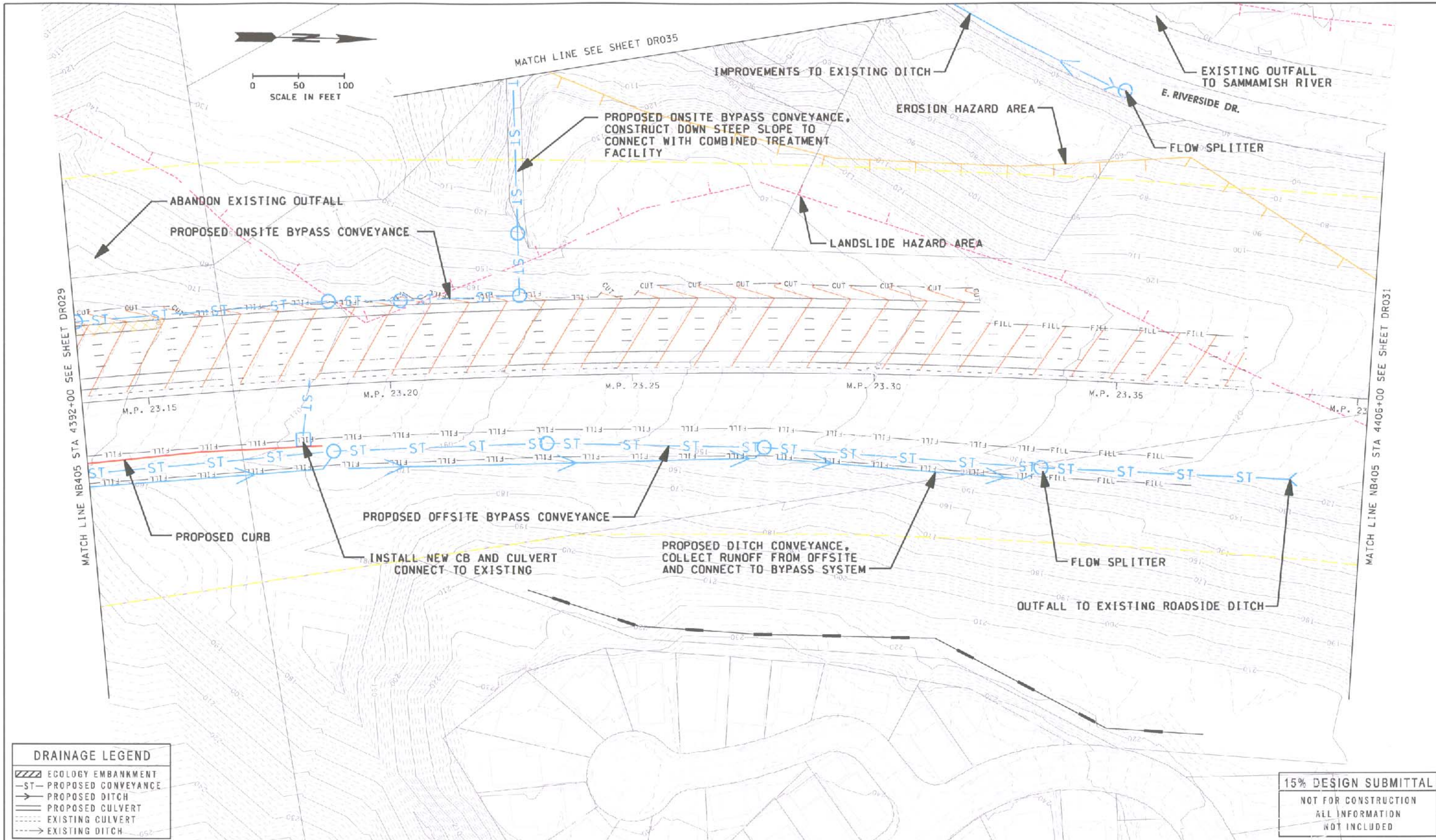

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REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
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CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

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Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR030

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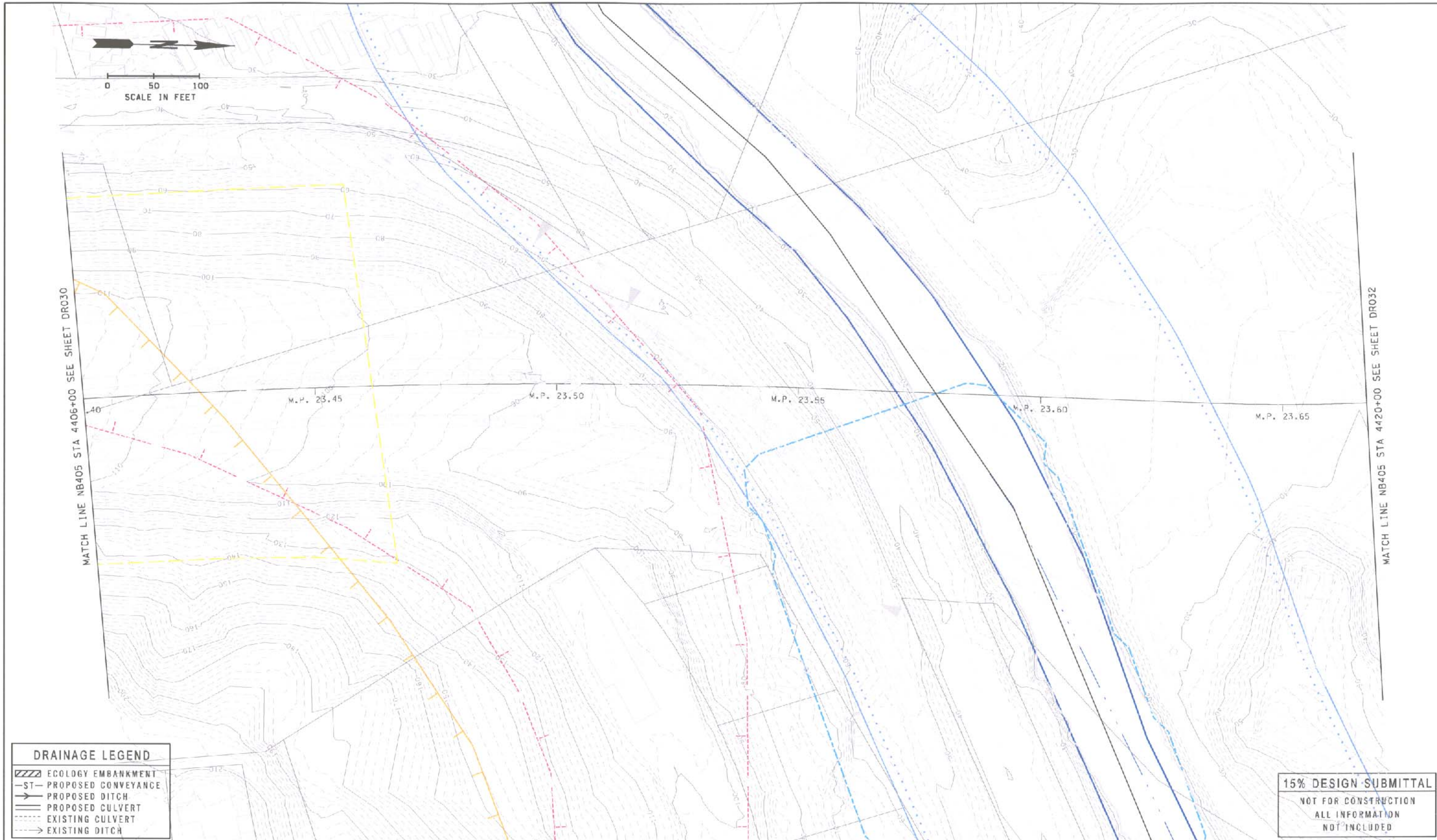

DRAINAGE LEGEND

- ECOLOGY EMBANKMENT
- —ST— PROPOSED CONVEYANCE
- PROPOSED DITCH
- PROPOSED CULVERT
- EXISTING CULVERT
- EXISTING DITCH

15% DESIGN SUBMITTAL

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JOB NUMBER		
CONTRACT NO.		LOCATION NO.

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INTERSTATE 405 Project Team

Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR031

SHEET 31 OF 35 SHEETS

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INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR032

SHEET 32 OF 35 SHEETS

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Washington State Department of Transportation

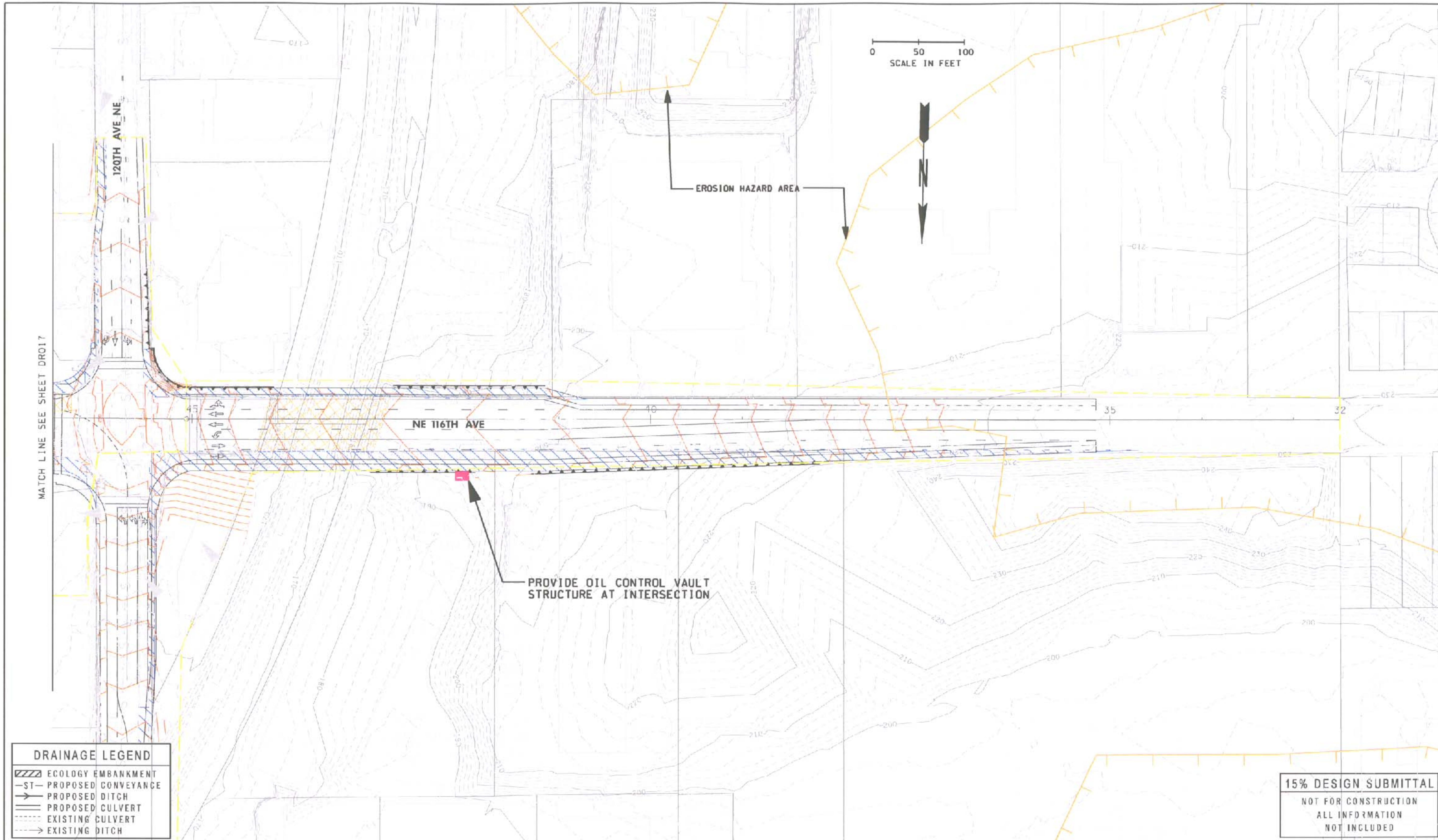
I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS KIRKLAND NICKEL

STAGE 2

DRAINAGE PLAN

DR033

SHEET 33 OF 35 SHEETS



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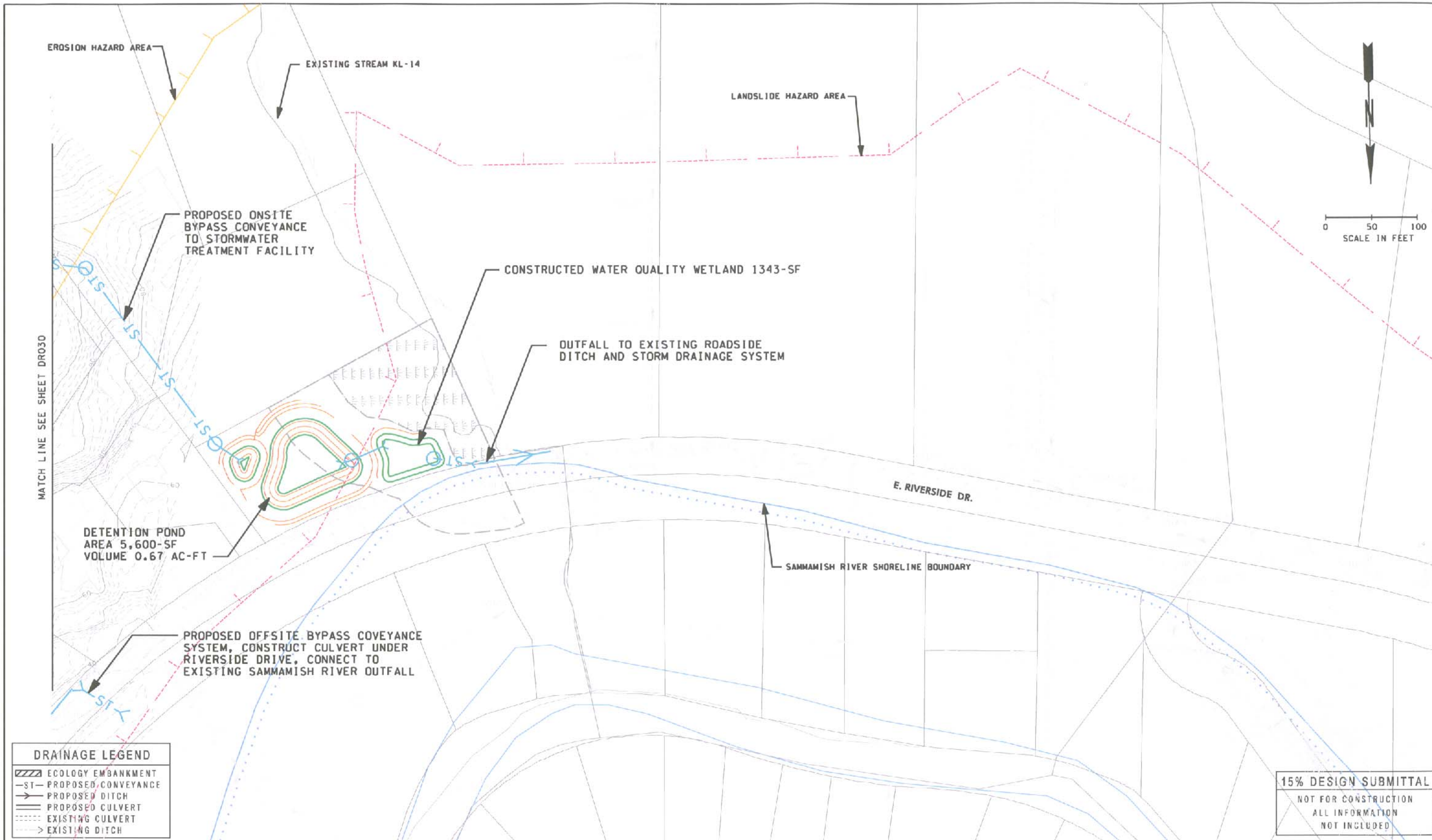
INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR034

SHEET 34 OF 35 SHEETS



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INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF & BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 2

DRAINAGE PLAN

DR035

SHEET 35 OF 35 SHEETS

APPENDIX C

STORMWATER DESIGN CRITERIA TECHNICAL MEMORANDUM

Stormwater Design Criteria Technical Memorandum

Date: **May 18, 2004**

Subject: **Stormwater Design Criteria for the I-405 Corridor**

INTRODUCTION

On June 3, 2003, a stormwater strategy workshop was held to refine the I-405 team strategy for the stormwater design. Based on the workshop report a Stormwater Strategy document was finalized and accepted as part of the project business plan. The primary goals of the Stormwater Strategy is to prepare stormwater management concepts that are practicable and permitable; provide the stormwater engineering documents necessary to facilitate environmental approvals and quantify land acquisition; and act as a basis for development of the bid price by the design-build constructors. The Stormwater Strategy document (March 2004) lists the design approach that will be used for the I-405 corridor stormwater design.

The purpose of this memo is to define the project specific design criteria, in accordance with the Stormwater Strategy's design approach. The design criteria is based primarily on the WSDOT Highway Runoff Manual (March, 2004) and is applicable to the full I-405 corridor project limits. There are also local jurisdiction requirements which impose additional criteria and regulations along the corridor. These are described in more detail within the applicable sections below.

GENERAL REQUIREMENTS

REFERENCES

A. Primary Criteria:

WSDOT Standard Plans M 21-01, January 2004.

WSDOT Hydraulics Manual M 23-03, March 2004.

WSDOT Highway Runoff Manual M 31-16, March 2004.

WSDOT Standard Specifications M 41-10, 2004.

B. Additional Design References and Information Sources

Washington State Department of Ecology (Ecology, WSDOE), Stormwater Management Manual for Western Washington (SMMWW), Volumes I – V, Final, August 2001.

King County, Washington, Surface Water Design Manual (KCSWDM)- adopted for public rule by the King County Executive on October 30, 1998, and published updates.

Ecology Non-point Source Pollution Assessment Project, October 1989, Publication #88-17

Washington State Water Quality Assessment: Year 2002 Section 305(b) Report, Publication #02-03-026

Federal Aviation Administration's (FAA) Advisory Circular 150/5200-33, FAA 1997

1998 Washington State Water Quality Assessment, Section 305(b) Report, Ecology

Green River Flood Control Zone District map, King County, November 2001

Inter-local Agreement for the Administration of the Green River Flood Control Zone District, July 2002

WSDOT NW Region Stormwater Report Template, Sept., 2003

May Creek Basin Plan (adopted by King County on April 23, 2001).

Coal Creek Basin Plan and FEIS (King County adopted 1987)

Cedar River Basin and Non-Point Action Plan (King County, adopted 1997),

Aquatic Habitat Guidelines, Design of Road Culverts for Fish Passage, Washington State Dept. of Fish and Wildlife, U.S. Fish and Wildlife Service, Washington State Dept. Of Transportation, U.S. Corps of Engineers and Washington State Dept. of Ecology, 2003

Fish Passage Design at Road Culverts, Washington Department of Fish and Wildlife, March 3, 1999

Renton Municipal Code, Ordinance 5020, September. 29, 2003

Kirkland Municipal Code, Ordinance 3908.

Snohomish Municipal Code, September 26, 2003.

Bellevue Municipal Code, Ordinance 5461 (City Code) and Ordinance 5404 (Land Use Code).

Bothell Municipal Code, Ordinance 1904.

City of Newcastle, WA, Municipal Code, Ordinance 2003-272, June 24, 2003.

Tukwila Municipal Code, Ordinance 2010, December 16, 2002.

Snohomish County Code.

WSDOT Design Manual, Section 1210, M22-01, December 2003.

National Resource Conservation Service, Soil Survey of King County Area Washington, compiled 1972.

HYDRAULICS

A. Design Frequency

See WSDOT Hydraulics Manual, page 1-7 for reference on the structure design mean recurrence interval (MRI) storm criteria.

- Bridges- Use one hundred year MRI for design of flow passage and foundation scour. Use five hundred year MRI for high flow damage. Additional fish passage requirements may be applicable per WSDOT Hydraulics Manual, Chapter 7 guidelines.
- Culverts- Where fish are present, the Washington State Dept. of Fish and Wildlife guidelines will be checked to ensure fish passage. See WSDOT Hydraulics Manual, Chapter 7 for culvert design guidance for fish passage. For standard culverts, the design for the head water (HW) depth above the invert of the culvert divided by the culvert diameter (D) ratio (HW/D) is based on the twenty five year MRI (normally HW/D equal or less than 1.25) with the one hundred year MRI checked for flow damage with no overtopping of the highway pavement. For bottomless culverts the design for HW depth is checked for both the twenty five MRI (normally maintain one foot minimum clearance between top and water surface) and the hundred year MRI (water surface not to exceed top of culvert).
- Storm Drain Trunk Lines- Pipes sized to convey the twenty five year MRI flow. Perform check that overtopping flows up to the hundred year MRI have a positive outlet without damage. Similarly, offsite areas conveyed across the corridor in separate storm drains should be checked for capacity where overtopping flows up to the one hundred year MRI is passed through or otherwise safely outletted without damage.
- Flow conveyance concepts will ensure that the quality and flow control design flows will reach the stormwater management facilities. (This may be a different flow than the peak flow per the MRI otherwise required by the WSDOT Hydraulics Manual.)
- Pavement Drainage- Inlets and inlet spacing will be designed for a 10-yr MRI storm. Lateral collection ditches and drains to be sized for the twenty-five year MRI and for a fifty year MRI for sump condition. The gutter flow width should not exceed the shoulder width plus half the adjacent lane width. However for the high-speed limited access type highways with wide shoulders, it is desirable to limit width of spread to the shoulder and/or shall not exceed 0.12 ft. depth at edge of traveled lane (page 5-3 WSDOT Hydraulics Manual). Super elevation transition crossover flows shall not exceed 0.10 cfs at point of zero super elevation (page 5-3 WSDOT Hydraulics Manual). In addition the velocity of gutter flow is not to present hazard to traffic, pedestrians or erosion. The hydraulic grade line is to be below structure rim elevation for peak design flow (page 6-9 WSDOT Hydraulics Manual).

B. Method for Calculating Runoff

Stormwater conveyance facilities use one of two methods for calculation of the applicable design flow rate. These two methods are also used for calculating total volumes when needed for sizing quality treatment BMPs.

- WSDOT Hydraulics Manual Figure 2-4.4B, "Seattle" values for "m" and "n" values or Western King County 24-Hour Precipitation Isopluvials are applied for the Rational Method on basins smaller than 10 acres [King County, Washington, Surface Water Design Manual, pp. 3-14 through 3-17].
- The Santa Barbara Unit Hydrograph (SBUH) method for basins 10 to 100 acres.
- For larger basins, subdivide the basin in smaller subbasins and route the associated subbasin flows along the flow paths for a combined hydrograph at the point of concern. The preferred SBUH modeling software for doing this is "StormShed".

Stormwater flow control facilities and flow rate based water quality treatment BMPs will be designed using the new WSDOT continuous flow model, "MGSFlood." Design quantity treatment criteria will differ depending on the location of discharge as noted in the Runoff Quantity Treatment section of this memo.

C. Drains and Culverts

- Velocities- Maintain minimum flow velocity of 3.0 feet per second (fps) to avoid siltation. Avoid excessively high velocities >10 fps to minimize pipe/culvert erosion. Pipe profile grades to be continuous with grade-breaks made at structures. No changes in pipe sizes between structures. Maximum spacing between inlets/manholes is 300 feet (500 feet for 48 inch and larger) (Ref. pages 3-55 and 6-1 to 6-3, Hydraulics Manual).
- Drain Line Sizes- Minimum sizes of 12 inches for parallel lateral drains and 18 inch for drain pipe lines under the corridor mainlines except for a single lateral less than 50 feet in length may be 8 inches (Ref. pages 3-55 and 6-2, Hydraulics Manual).
- Cross-Drain Culvert Sizes- Section 3-5.3 of the Hydraulics Manual requires a minimum pipe size for culverts of 18". For this project, a minimum size of 24" should be used where crossing the main corridor traffic lanes, otherwise 18" diameter is the minimum to be used. Pipes under roadway approaches may be a minimum of 12 inch diameter (Ref page 3-55 Hydraulics Manual).
- Erosion Control- Energy dissipation or erosion control measures to be checked in ditches and pipe outlets where design year velocities exceed 5 fps (Ref. Highway Runoff Manual Chapter 5 and Hydraulics Manual Section 3-4 for general erosion control measures).

RUNOFF TREATMENT

Chapter 2 of the WSDOT Highway Runoff Manual (HRM) describes nine minimum requirements that must be considered during the planning, design and construction phases of each project. Not all of the nine requirements apply to every project. The thresholds and applicability information noted in Section 2-2 of the HRM must be considered in determining which of the minimum requirements must be applied. The minimum requirements that need to be used will be determined on a basin by basin basis.

Good engineering judgment should be used to apply the HRM criteria with regard to one of the main goals of this project, "leave the environment a better place." So instead of taking a minimal criteria approach, the designer's attitude will be to provide treatment for as much of the project pollution generating impervious surfaces as physically and financially practical.

RUNOFF QUANTITY TREATMENT

According to the WSDOT Highway Runoff Manual infiltration is the first measure to be considered for runoff treatment. Combine infiltration with surface discharge to minimize detention volumes wherever possible. Draw-down of infiltration detention should be done within 48 hours after the end of the design storm event.

Stormwater surface discharges must match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow. The existing project area land cover condition is used as the pre-developed condition where: 1) no flow control exemptions exist; 2) no approved basin plans exist that address hydrologic modeling input parameters for stormwater system design; 3) the site cannot reliably infiltrate all its runoff; or 4) the existing site condition is not forested (WSDOT Highway Runoff Model, page 4-17). If a project will revert any of the existing impervious surface back to a pervious condition that portion of existing impervious surface can be modeled as grass. With this approach, the areas of existing pervious and impervious surfaces must be defined within each basin. Note: Use the WSDOE SMMWW manual criteria that requires the pre-developed condition be the pre-European condition or forested (use 75% forest, 25% prairie as per internal memos defining that the pre-European condition was not all forest due to forest fire action) only if required per specific project administrative policy (to respond to permitting issues).

The WSDOT model "MGSFlood" will be used for the continuous simulation model for design of flow control detention facilities.

Improvements which increase outlet flows by less than 0.1 cubic feet per second (cfs) for the 100-yr event storm are exempt from quantity treatment. Other exceptions are direct discharges to Lake Washington (WSDOT Highway Runoff Manual, March 2004, page 2-22); Sammamish River (King County Surface Water Design Manual, September 1998, page 1-29); Cedar River (Lower Cedar River Basin and Nonpoint Pollution Action Plan, Adopted by the Metropolitan King County Council, King County Dept. of Natural Resources, 1998, pages 4-65 and 4-71); other flow controls that may be discovered during the course of the design work for streams that have hydrologic discharge thresholds defined per an adopted basin plan or downstream flooding problems; and exceptions on project discharges to existing municipal/county storm drain systems where the rate of project discharge is limited to the available capacity of the system as determined by the agency. Note that runoff quality and spill control treatment facilities are still required for these exempt discharges.

RUNOFF QUALITY TREATMENT

Per the WSDOT Highway Runoff Manual (HRM), there are three basic steps to applying runoff treatment to a project during planning and design: 1) Determine the specific runoff treatment requirements (i.e. targets). Refer to Section 2-3.5.4.1, Chapter 3 and Chapter 4 of the HRM. 2) Choose the method(s) of runoff treatment that will meet the treatment requirements and is most suited to the constraints/opportunities presented by the project's context. Refer to Chapter 3, Chapter 4, and Chapter 5 of the HRM. 3) Design runoff treatment facilities based on the criteria for sizing runoff treatment facilities. Refer to Section 2-3.5.4.2, Chapter 4, Chapter 5 of the HRM, and the WSDOT Maintenance Manual.

The design approach is one that mimics natural hydrology where feasible, through the dispersal and infiltration of runoff. The extent to which runoff flow rates and volumes can be dispersed and then infiltrated determines the types of runoff treatment facilities that can be used and the size of those facilities. This is discussed in detail in Chapters 3, 4, and 5 of the HRM.

There are four runoff treatment targets: Basic Treatment, Enhanced Treatment, Oil Control, and Phosphorus Control. The HRM, Table 2-1 describes when the treatment targets must be applied and performance goal for each. Table 2-2 identifies receiving waters that do not require Enhanced Treatment for direct discharges. Enhanced Treatment is required wherever the Basic Treatment is required and the roadway ADT is equal to or greater than 30,000 (or otherwise required by an adopted basin plan). Similarly, Oil Control is required wherever the Basic Treatment is required and there is an intersection where a roadway with ADT equal to or greater than 15,000 crosses a roadway with ADT equal to or greater than 25,000 (also see the table for Oil Control requirements for rest areas, parking lots and maintenance areas). Phosphorus Control is used wherever Basic Treatment is required and the project is in a designated area dictated for Phosphorus Control by an adopted basin plan. There are no currently known Phosphorus Control designated areas along the I-405 Corridor.

The following technologies should be considered for Basic Treatment: biofiltration swales, filter strips, basic wetponds, combined detention and wetpool facilities, stormwater treatment wetland, and wetvaults or combined detention/wetvaults. The sizing of flow rate based BMPs (biofiltration swales, filter strips and oil-water separators) is based on achieving a minimum contact-residence time, designed to treat 91% of the mean annual runoff volume as determined by the continuous runoff model. Volume based runoff BMPs (wetpool facilities) are designed to treat the runoff volume from a 6-month, 24-hr design storm (72% of the 2-yr, 24-hr storm). See Chapter 5 of the HRM for a more complete description of BMPs and the associated selection process.

Enhanced Treatment is to provide a higher level of dissolved metals removal then done by the Basic Treatment BMPs. Typical Enhanced Treatment BMPs are: compost-amended vegetated filter strip; ecology embankment; constructed stormwater treatment wetland; sand filter basin; linear sand filter (large); sand filter vault (large); and a two facility treatment train. There are also some experimental Enhanced Treatment BMPs that could be considered such as: roadside bioretention; modified biofiltration swale; wet pond modifications; filter media systems; and amended sand filter. The experimental BMPs need further refinement and could be installed as a pilot project with special DOT permission as they currently are not permitable (See Appendix 5B, HRM for more details).

Limited impact development (LID) treatment BMPs should be considered for use wherever possible. LID's by their nature will help to reduce costs and right-of-way impacts over the more traditional runoff treatment facilities. Potential LID use on the I-405 corridor has been identified in a draft report titled, "The Potential for Utilization of Innovative Stormwater Source Control and Natural Treatment Techniques on Interstate-405 in the North Renton Project Area", dated October 2003, by Battelle Marine Sciences Laboratory. One of the LID BMPs that is particularly applicable for the I-405 project is the Ecology Embankment/Ditch using an compost amended filter and under-drain system built into the side slope and/or collector ditch beside the shoulder.

There are specific sole source aquifer and well head protection areas within the project corridor where infiltration is not permitted. There are also other areas where soil and groundwater conditions will limit infiltration opportunities. In these areas basic and enhanced quality treatment options may consist of sand or biological gravity type filtration systems. These types of treatments have traditionally been discouraged due to the higher levels of maintenance required. However, if this type of filtration becomes the selected treatment facility, than WSDOT maintenance section should be consulted during the design process.

Stormwater management facilities will include spill control measures to prevent damage to the proposed highway facilities and adjacent property.

ADDITIONAL CRITERIA

- Requirements for stormwater facilities in wildlife hazard management areas- Sites within 10,000 feet of a aircraft operation area as defined by the FAA, should discourage use by wildlife, in particular use of open ponds are limited or otherwise designed to discourage use by ducks and geese. See Federal Aviation Administration's (FAA) Advisory Circular 150/5200-33, FAA 1997. This will apply to the I-405 corridor area adjacent to the City of Renton Municipal Airport.

- There are sole source aquifer and well head protection areas within the project corridor. Most notably is the City of Renton sole source aquifer with two separate zones, where zone one allows no infiltration and zone 2 allows infiltration only after quality treatment. There are also well head protection zones, mandated by city and county ordinances, but typically require that no infiltration is allowed within 100' of any potable water well. (Likewise, county and city ordinances should be checked as to infiltration clearances adjacent to any existing septic systems. They normally require at least a 100' set-back.)

- Discharge to county or municipal storm drains will require coordination with the applicable agency and evaluation of the existing storm drain capacity. If capacity is available, then acceptance of the strategy and development of operation and maintenance agreements is required by WSDOT and the agency.

- Although storm drainage facilities are to be designed per the WSDOT approved criteria listed in this memo, the project will perform improvements to adjacent city and county roads and streets. These improvements most likely will be "turned-back" to the county or city for their jurisdiction and for long term operation and maintenance. As such, turn-back agreements will usually require that the design and construction of the facilities, including the stormwater facility, be based on their local criteria and standards. Accordingly, each local jurisdictions design standards should be reviewed and any that are not in accordance with WSDOT standards, should be so noted and allowances be made to include the specific item in the design. These will probably include not only specific geometric standard differences, but varying design criteria and use of local standard structures and inlets, in particular grates and covers for standardization with other city/county facilities. Different construction material specifications may also be required. Specific WSDOT acceptance is required prior to applying other jurisdiction standards using the WSDOT standards exception process.

- Runoff treatment along the corridor may be mitigated by upstream watershed basin improvements, also performed by the projects. Watershed mitigation opportunities will be determined by WSDOT and project team task forces. The drainage design team will provide hydraulic design support as may be required.

- Design concepts need to consider how the storm drainage will be incorporated into a phased construction project. The stormwater treatment facility for the full ultimate footprint design may not have to be initially constructed for a partial implementation or nickel funding sized initial construction phase. Likewise, consideration of how the construction will actually be done, per staging concepts or per implementation stage may also influence what drainage facilities get constructed when. This will be evaluated with the help of the other I-405 design team discipline groups.

DESIGN APPROACH

The I-405 corridor improvements are going to be constructed by the design-build type process, where final design is done in conjunction with the construction by a design-build contractor. Accordingly, drainage designs will not be completed to a typical PS&E finished product, but will be only taken to a conceptual level by the I-405 team. The conceptual drainage design will be completed enough to define conveyance and treatment concepts to a level required for right-of-way purchase, permitting, and when combined with performance specifications as a basis for the design-builder to price the final design and construction work. A preliminary example of this type of performance specification is as follows:

"The contractor shall provide FLOW CONTROL within existing WSDOT right-of-way (thus limiting additional wetland and buffer impacts) using one of the following options:

- Infiltration galleries, pond or vaults
- Detention ponds or vaults
- Combined detention/infiltration ponds or vaults
- Wetland mitigation sites

- Regional detention facilities
- Except where discharging to exempted water bodies.

The drainage design documents provide one solution that illustrates the basis of estimate and land acquisition, but the contractor is encouraged to seek more cost effective solutions. These facilities shall be sized according to the methods described in the project design criteria document.

The contractor shall provide WATER QUALITY TREATMENT for the 6-month design storm event runoff volume for wet pool facilities or achieving the minimum contact-residence time for treating 91% of the mean annual runoff volume for flow-rate based treatment facilities within existing WSDOT right-of-way using one of the following options:

- Discharge the water quality design storm through infiltration galleries, pond or vaults
- Ecology swales and embankments
- Biofiltration swale and strips
- Catch basins, wet ponds and wet vaults
- Wetpond with emergent aquatic plants
- Media filters

The drainage design documents provide one solution that illustrates the basis of estimate and land acquisition, but the contractor is encouraged to seek more cost effective solutions. These facilities shall be sized according to the methods described in the project design criteria document."

Additional items that need to be considered and evaluated for the I-405 corridor drainage design and included in the contract requirements for the design-builders are listed below.

Recommendation/Limitations for Cost Saving Measures

- Use porous pavements
- Use bio-retention and Ecology fill
- Use infiltration within the roadway embankment prism
- Consider tree replacement requirements
- Use of watershed-based mitigation
- Select open pond versus structural vault storage where possible.
- Explore possible methods for allowing unapproved/proprietary measures Temporary Erosion and Sediment Control

Applying the WSDOT Highway Runoff Manual, Minimum Requirement # 1, *Erosion and Sediment Control* requires that construction of the project comply with applicable state water quality standards. The WSDOE SMMWW includes a complete list of those state standards in Volume II, "Construction Stormwater Pollution Prevention, and "Section 2.3.2," Compliance with Standards." It will be the design-builder's responsibility to develop the project TESC plans according to his construction staging and phasing program.

Maintaining the Natural Drainage System

The WSDOT HRM Minimum Requirement # 4, *Maintaining the Natural Drainage System*, states that to the maximum extent possible, natural drainage patterns must be maintained, and discharges from the site must occur at the natural outfall locations.

In addition for adjacent property impact considerations, the King County SWDM Core Requirement # 1, *Discharge at a Natural Location*, adds that a conveyance system should carry concentrated runoff across the downstream properties to an acceptable discharge point. In the event that this is not possible, the KCSWDM provides design guidelines (section 6.2.6.1) for flow spreader trenches that would effectively disperse flows to uniform sheet flow conditions.

There may be a few locations where the project will maintain existing hydrologic functions that have been in place since the original I-405 construction, rather than restoring the original basin. For instance, some of the existing stream crossings (i.e. Coal Creek) have been modified from the original channel. Typically, the proposed improvements will not restore the channel back to original location, unless otherwise specifically identified as a project need.

Conveyance Systems

Capacity:

New and replaced pipe systems would be designed to convey and contain peak flows assuming developed conditions for onsite tributary areas and existing conditions for any offsite tributary areas. The WSDOT Hydraulics Manual (Section 1.4) gives the 25-year recurrence interval as the minimum design criterion for sizing of storm drain trunks, but the design year MRI could be controlled by the flow control requirements. If detention is required to control the 50-year MRI discharges from the site, it will be necessary to design the drain trunk to convey the runoff to that facility. Refer to the Water Quantity Treatment Section of this memo for additional details.

New and replaced culverts and ditches/swales/channels will be designed to convey and contain the 100-year peak flow, assuming developed conditions for onsite tributary areas and existing conditions for any offsite tributary areas. This design capacity shall not create or aggravate severe flooding problems downstream. New or replaced culverts on cross-drainage where fish are identified shall be designed for fish passage.

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Analysis of Existing Systems:

When checking capacity constraints of enclosed drainage systems:

- Evaluation of existing conveyance systems should be based on the WSDOT conveyance calculations when available.

- The 25-year Mean Recurrence Interval (MRI) would apply, unless previous design documents specify 50-year MRI.

The analysis should show that the design peak runoff is less than the pipe capacity. If the additional impervious surface results in a design runoff that exceeds the pipe capacity, the pipe sections would be considered inadequate and replaced.

Pipe Cover

Subsurface conveyance systems shall use the WSDOT Hydraulics Manual Fill Height Tables in section 8-11, for minimum cover and pipe types per cover depths under roadway sections. Verify that all pipes are outside the roadway section and that there would be sufficient cover to connect new inlet laterals to existing conveyance structures. Address inadequate pipe cover areas by reconstructing the existing systems or by providing a new conveyance system. Consider alternative pipe materials and anchors as required to meet the specific cover, slope and soil conductivity along the conveyance system.

When designing drainage for adjacent county streets and roads, KCSWDM Core Requirement # 4, *Conveyance System*, requires that the ditches, swales, storm sewers, and culverts will be analyzed, designed, and constructed to provide a minimum level of protection against overtopping, flooding, erosion, and structural failure.

Pipe type selection should be in accordance with Chapter 8 of the WSDOT Hydraulics Manual.

Source Control of Pollutants

The WSDOT HRM Minimum Requirement # 3, *Source Control of Pollutants* lists a number of things that can be done to help control pollutants, most of which are done during the construction and maintenance phases. This includes a requirement that a spill control and containment plan and an erosion and sediment control plan be developed for the project. These will be the responsibility of the design-builder to prepare and maintain during the construction work.

Wetlands

WSDOT HRM Minimum Requirement # 7, *Wetlands Protection*, requires that stormwater runoff discharging to a wetland be treated for water quality and quantity in a manner consistent with that otherwise described for runoff quantity and quality treatment. Each wetland will be evaluated on a case-by-case basis to determine impacts of stormwater discharges. The diversity in the values and functions of a wetland, as well as the uniqueness of the type of wetland, will need to be understood before determining if the treatment provided by the runoff quality and quantity criteria will adequately protect the receiving wetland. If a wetland mitigation site is created to replace wetlands that were unavoidably destroyed during design and construction of the project corridor, that site will not be used for stormwater treatment. Stormwater treatment wetponds can be designed to treat stormwater runoff, but it cannot be in an area that is considered a preserved wetland.

Offsite Analysis

Offsite drainage areas will be determined, the hydrology calculated and conveyance facilities checked or designed. For the general case, offsite drainage should be passed through the corridor, separate from the on-site treatment system, matching the pre-project drainage pattern. Where co-mingling of off-site and on-site flows cannot be avoided, then the treatment system must be designed to accommodate the combined flows. For larger watersheds having gauged hydraulic data and/or specific agency plans, then the hydrology data will be defined by the appropriate floodplain or basin study.

Incorporation of Watershed-based Basin Planning into Stormwater Management

For adopted watershed basin plans within the vicinity of the I-405 corridor, the various stakeholders will operate, build and maintain the recommended facilities per the plan. The proposed I-405 improvements however, should be compatible with the various plans. In particular any special downstream requirements will be identified and documented in the project stormwater reports.

WSDOT HRM Minimum Requirement # 8, *Incorporating Watershed-Based/Basin Planning Into Stormwater Management*, requires that the methodology found in existing basin plans shall be used. Incorporating watershed-based / basin planning into stormwater management requires that the basin / watershed plans must evaluate and include, as necessary, retrofitting urban stormwater BMPs into existing development or redevelopment in order to achieve watershed-wide pollutant reduction and flow control goals consistent with requirements of the Federal clean Water Act.

Construction Stormwater Pollution Prevention Planning

The WSDOT HRM Minimum Requirement # 1, Stormwater Planning and Minimum Requirement #2, Construction Stormwater Pollution Prevention, will be complied with separately, by each design-builder for their specific project. The Temporary Erosion and Sediment Control (TESC) Plan and the Spill Prevention, Control, and Countermeasures (SPCC) Plan shall be prepared in accordance with the detailed elements in Sections 6-2 and 6-3 of the WSDOT HRM.

APPENDIX D

STORMWATER DESIGN DECISION REPORTS

INTERSTATE 405 **Project Team**

Congestion Relief & Bus Rapid Transit Projects

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Stormwater Design Decision
Treatment of Runoff From New Impervious Surfaces
Kirkland Nickel Project

July 23, 2004

Washington State
Department of Transportation

Introduction

The purpose of this paper is to define "new", "replaced" and "effective" impervious surfaces for purposes of determining and calculating minimum treatment requirements for storm water runoff within the Kirkland Nickel Project.

Background

The Kirkland Nickel Project drainage design is in accordance with the WSDOT Highway Runoff Manual (HRM), March 2004. Minimum runoff treatment requirements are selected using the flow chart procedure listed on page 2-3 of the HRM. The HRM procedures requires that the project existing, new and replaced pavement surface areas (impervious areas) be measured. The minimum runoff treatment requirements are first selected on a project area basis to decide which of the HRM's nine minimum requirements are applicable. If the project area has more than the minimum of 5,000 sq. ft. of new impervious area, then the new pavement must be treated with both quality and quantity controls. If the new impervious surface is more than 50% of the existing impervious surface then both the new and replaced impervious surfaces must be treated.

The Kirkland Nickel Project has over 5,000 square feet of new impervious area so minimum requirements 1 through 9 apply to the new pavement. However, the new pavement surface adds only about 17% of existing pavement surface so replaced pavement does not need to be treated.

The HRM then looks at the individual threshold discharge areas (TDAs) to decide whether the minimum runoff treatment requirements determined for the project wide basis need to be used at the TDA level. If the new pollution generating impervious surface (for Kirkland Nickel this is the same as the new pavement area since we do not have greater than 50% new pavement) is 5,000 square feet or greater within a given TDA, then minimum requirement no. 5, Runoff Treatment is applied to the new pavement areas in that TDA. If the new impervious area is 5,000 square feet or more in a given TDA, then minimum requirement no. 6, Flow Control is applied to the new pavement areas in that TDA.

In summary, several of the Kirkland Nickel Project TDA's will have minimal new pavement added (less than 5,000sf), where minimum HRM requirements for runoff quality treatment and flow control do not need to be applied. Where the minimum thresholds are met in the other TDAs the new pavement areas tend to be small widened slivers and the required runoff treatment facilities are relatively small (as compared to a full rebuild type of highway project).

This above procedure generally follows the same requirements outlined in the Washington Department of Ecology Stormwater Management Manual for Western Washington dated

August, 2001 (SMMWW). Although there are some differences in allowable minimum disturbance areas between the two manuals, the same basic conclusions on applying minimum runoff treatment requirements will be reached using ether the HRM or the SMMWW if the same definitions of "new", "replaced" and "effective" impervious surfaces are used.

To date there have been a number of differing interpretations made by members of the I-405 team and the WSDOT HQ Hydraulics Office as to how to apply and model the runoff from the "new", "replaced" and "effective" impervious surfaces. This has resulted in several drainage design iterations and revisions based on both discipline team discussions as well as higher level technical review comments. The WSDOT HQ Hydraulics Office (Alex Nguyen) has recently held discussions with DOE (*Ed O'Brien)* clarifying the usage of the terms "new", "replaced" and "effective" as follows:

- New Impervious Surface – For the Kirkland Nickel Project, this would be the new widened pavement area, the new pavement outside of the existing pavement cross-section beyond the existing edge of shoulder. This is new pavement covering existing pervious area. New impervious surfaces are also those gravel surfaces that are upgraded to ACP or PCCP. For the general case, the new impervious surfaces could also be the new pollution generating impervious areas with the exception of road separated bike paths and sidewalks.
- Replaced Impervious Surface –This is existing pavement that is removed into bare soil and a new pavement section installed. For the Kirkland Nickel Project, the replacement of existing shoulders with full depth pavement is considered replaced pavement. (Note: Grinding and repaving operations are not considered replaced pavement).
- Effective Impervious Surface – For the Kirkland Nickel Project this is the same surface area as the New Impervious Surface. If on another project the amount of new pavement were to be greater than 50% of existing pavement, then you would add the replaced pavement quantity to the new pavement quantity to find the impervious surface requiring treatment.

The above definitions of terms was passed on to theI-405 drainage discipline team from Alex Nguyen in a meeting held on July 12, 2004, and further clarified in a telephone conversation on July 20th. Based on these clarifications, the I-405 drainage designers will proceed with finalizing the Kirkland Nickel Project drainage concepts wherein the final treatment modeling will be providing runoff quality and quantity treatment only for the "new" pavement as defined above, per the requirements for minimum treatment listed in the HRM. In effect, the runoff treatment will utilize the following constraints:

- Quantity (flow control) treatment will be modeled for the new impervious area only. In some threshold discharge areas (TDAs) there is less than the minimum required new pavement area of 5,000 square feet and no flow control treatment will be required. Equivalent area calculations will be used to place detention facilities at locations that minimize new conveyance pipes and ditches, and the resulting disturbance of existing pavement. Infiltration will also be used wherever possible to reduce detention structure sizes.

- Quality treatment will be modeled for the new impervious area only. Every effort will be made to treat the new pavement areas directly. However equivalent area modeling may have to be done at some locations where it is impossible to catch the new pavement runoff without installing a new collection system.
- Quality treatment facilities at times may be sized not only for runoff from the new impervious surface but may include other off-site, corridor pervious area, existing impervious surface, or replaced impervious surface runoff that is mixed into the new pavement runoff. This will in effect, retrofit treatment for a portion of the existing and /or replaced pavement surface. The actual areas of new, existing and replaced pavement surfaces where runoff is actually collected and treated will be measured and quantified in the project hydraulic report and appropriate environmental discipline reports.

Summary

This paper concludes the Kirkland Nickel Project will define "new impervious surface" as new pavement that will cover existing pervious area, widened outside of the existing edge of shoulder; "replaced impervious surface" as existing pavement removed into bare soil and replaced with a new pavement section; and "effective impervious surface" is the same area as the new impervious surface. These definitions are for purposes of determining the HRM minimum runoff treatment requirements to be used for the Kirkland Nickel Project. This definition is summarized on the attached standard roadway sections drawing, Exhibit 1.

This decision was based on information gathered dealing with the following main factors:

- The design direction given by Alex Nguyen, WSDOT HQ Hydraulics Engineer and his discussions with DOE.
- The same clarifications will be formalized criteria in the next HRM update.
- The need to finalize the drainage concept to fit within the Kirkland Nickel Project's aggressive permitting and contract award schedule.

Further, Alex Nguyen will work to update the current HRM to clarify areas noted above such as the definition of effective impervious surface and clarifying the triggers listed in minimum requirements 5 and 6. Based on Alex's conversations with Ed Obrien, DOE feels that their manual is already clear, thus not requiring any modifications.

Decision Summary

Based on this paper's above discussion, the determination has been made to have the Kirkland Nickel Project to use the definition of "new impervious surface" as being the area of new pavement outside of the existing pavement footprint; "replaced impervious surface" as existing pavement removed into bare soil and replaced with a new pavement section; and "effective impervious area" as the same pavement area as the new impervious surface for purposes of determining stormwater treatment minimum requirements. It is also determined that in using these definitions, there should be little risk that the resultant runoff treatment facilities developed using the HRM procedures, will differ notably from facilities developed using the DOE Stormwater Management Manual for Western Washington (through the time period of the Kirkland Nickel Project RFP development).

Concurring Approvals:

Alex Nguyen 8/30/04

Alex Nguyen — Date

Matt Witecki 8/24/04

Matt Witecki — Date

Attachments : Exhibit 1.

INTERSTATE 405 Project Team
Congestion Relief & Bus Rapid Transit Projects

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Stormwater Design Decision
Treatment of Runoff From New Impervious Surfaces
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July 23, 2004

Washington State
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The Kirkland Nickel Project has over 5,000 square feet of new impervious area so minimum requirements 1 through 9 apply to the new pavement. However, the new pavement surface adds only about 17% of existing pavement surface so replaced pavement does not need to be treated.

The HRM then looks at the individual threshold discharge areas (TDAs) to decide whether the minimum runoff treatment requirements determined for the project wide basis need to be used at the TDA level. If the new pollution generating impervious surface (for Kirkland Nickel this is the same as the new pavement area since we do not have greater than 50% new pavement) is 5,000 square feet or greater within a given TDA, then minimum requirement no. 5, Runoff Treatment is applied to the new pavement areas in that TDA. If the new impervious area is 5,000 square feet or more in a given TDA, then minimum requirement no. 6, Flow Control is applied to the new pavement areas in that TDA.

In summary, several of the Kirkland Nickel Project TDA's will have minimal new pavement added (less than 5,000sf), where minimum HRM requirements for runoff quality treatment and flow control do not need to be applied. Where the minimum thresholds are met in the other TDAs the new pavement areas tend to be small widened slivers and the required runoff treatment facilities are relatively small (as compared to a full rebuild type of highway project).

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To date there have been a number of differing interpretations made by members of the I-405 team and the WSDOT HQ Hydraulics Office as to how to apply and model the runoff from the "new", "replaced" and "effective" impervious surfaces. This has resulted in several drainage design iterations and revisions based on both discipline team discussions as well as higher level technical review comments. The WSDOT HQ Hydraulics Office (Alex Nguyen) has recently held discussions with DOE (*Ed O'Brien)* clarifying the usage of the terms "new", "replaced" and "effective" as follows:

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Concurring Approvals:

Alex Nguyen — 8/30/04
Date

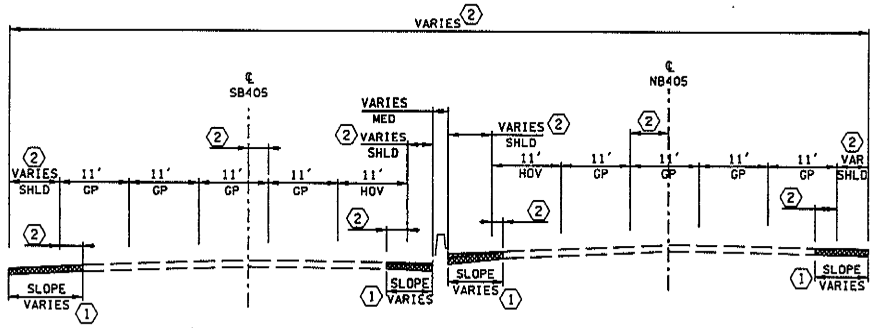
Matt Witecki — 8/24/04
Date

Attachments : Exhibit 1.

ATTACHMENT:

Exhibit 1, Typical Pavement Sections Showing Definition of New Pavement for Purposes of Determining Minimum Runoff Treatment Requirements for the Kirkland Nickel Project. (click on the embedded icon to open and print)

\\Seaw405\
405ProjCad\000\user



I-405 - NB 4 GP & 1 HOV LANE, SB 4 GP & 1 HOV LANE
RESTRIPE LANES REPLACE SHOULDERS, DEVIATED SECTION

SB405 STA 4144+20 TO STA 4148+10 (3)
SB405 STA 4224+14 TO STA 4227+90

NB405 STA 4140+20 TO STA 4141+40 (3)

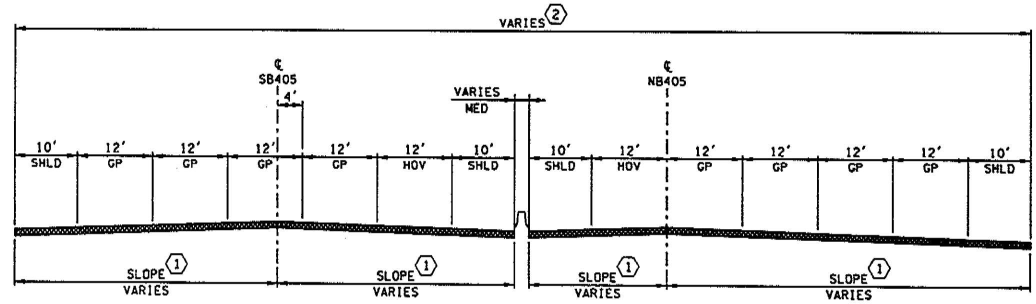
NOTES

(1) MATCH EXISTING SLOPE OF TRAVELED WAY

(2) DISTANCE VARIES, SEE PAVING PLAN SHEETS FOR DETAILS

(3) 4 GP, 1 HOV & 1 AUX LANE BETWEEN NE 70TH ST. AND NE 85TH ST.

REMOVE AND REPLACE EXISTING PAVEMENT



I-405 - NB 4 GP & 1 HOV LANE, SB 4 GP & 1 HOV LANE
FULL REPLACEMENT SECTION

SB405 STA 4200+36 TO STA 4224+14

NB405 STA 4190+85 TO STA 4225+10

NOTES

(1) SUPERELEVATION VARIES

(2) DISTANCE VARIES, SEE PAVING PLAN SHEETS FOR DETAILS

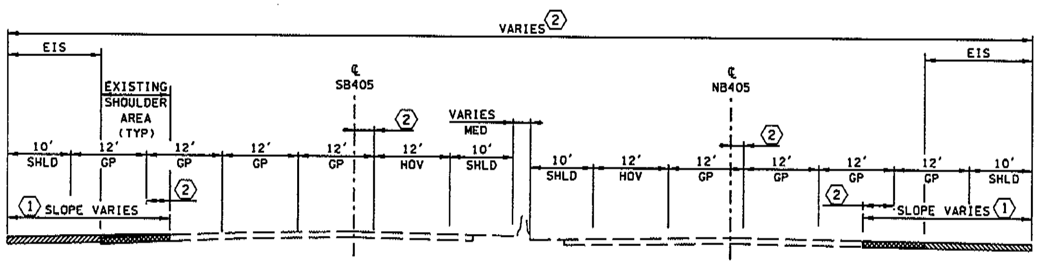
REMOVE AND REPLACE EXISTING PAVEMENT

Drainage Notes:

1. "New Impervious Surface" is defined as the new pavement (Widened area beyond the existing shoulder) as shown on this drawing for purposes of applying minimum treatment requirements per procedure on page 2-3 of the WSDOT Highway Runoff Manual, March, 2004 (HRM).

2. The effective impervious surface (EIS) is used to determine if HRM minimum requirement no. 6 (flow control) is applied at a threshold discharge area (TDA) level (page 2-24, HRM). Typically, the shown EIS is also the effective pollution generating impervious surface (EPGIS) that is used to determine if HRM minimum requirement no. 5 (quality treatment) is applied at a TDA level (page 2-14, HRM).

3. For Kirkland Nickel Project where new impervious surface area is < 50% of existing impervious surface, Flow control calculations are based on the "New Impervious Surface" as defined in drainage note 1. Quality treatment calculations are based on the EPGIS, plus any existing impervious surface, off-site and pervious ROW area flows that are mixed in with the new impervious surface runoff flows.



I-405 - NB 4 GP & 1 HOV LANE, SB 4 GP & 1 HOV LANE
WIDEN PAVEMENT, FULL STANDARD SECTION

SB405 STA 4148+10 TO STA 4200+36

NB405 STA 4141+40 TO STA 4190+85
NB405 STA 4225+10 TO STA 4228+80

NOTES

(1) MATCH EXISTING SLOPE OF TRAVELED WAY

(2) DISTANCE VARIES, SEE PAVING PLAN SHEETS FOR DETAILS

REMOVE AND REPLACE EXISTING PAVEMENT

NEW PAVEMENT

EIS = Effective Impervious Surface (typically can also be the Effective Pollution Generating Impervious Surface). See drainage note 2.

STORMWATER DESIGN DECISIONS
TREATMENT OF RUNOFF FROM NEW IMPERVIOUS SURFACES

EXHIBIT 1,
NEW AND REPLACED PAVEMENT
JULY, 2004

FILE NAME C:\pwworking\dms02153\Drainage_Section_Exhibit.dgn
TIME 3:09:29 PM
DATE 7/14/2004
PLOTTED BY chriss
DESIGNED BY X.XXXXXXXXXXXXXXX
ENTERED BY X.XXXXXXXXXXXXXXX
CHECKED BY X.XXXXXXXXXXXXXXX
PROJ. ENGR. X.XXXXXXXXXXXXXXX
REGIONAL ADM. X.XXXXXXXXXXXXXXX

REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	

JOB NUMBER
CONTRACT NO.
LOCATION NO.

P.E. STAMP BOX DATE
P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405 CONGESTION RELIEF &
BUS RAPID TRANSIT PROJECTS
KIRKLAND NICKEL
STAGE 1

ROADWAY SECTIONS

SHEET OF XXX SHEETS

INTERSTATE 405 Project Team
Congestion Relief & Bus Rapid Transit Projects

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Stormwater Design Decision Infiltration Investigations I-405 Nickel Projects

August 1, 2004
Author: K. Hixson

Washington State Department of Transportation

INTERSTATE 405 **Project Team**

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Stormwater Design Decision
Infiltration Investigations
I-405 Nickel Projects

August 1, 2004
Author: K. Hixson

Washington State Department of Transportation

Introduction

The purpose of this paper is to formalize and document the decision to use a concept level geotechnical investigation procedure for determining stormwater infiltration rates for the I-405 Corridor Nickel Projects.

Background

The initial baseline drainage concept designs for the Kirkland Nickel Project contained no infiltration provisions. A value engineering (VE) study was done in April 2004, which suggested that the geology and soils condition along the Kirkland Section should be able to accommodate runoff infiltration, along with cost savings in detention structures. Old soil boring records in the vicinity generally confirm this conclusion, but are not specific enough to establish detailed design parameters for ground water or infiltration rates.

Incorporating the VE recommendations, the I-405 drainage designers remodeled the detention volumes to include infiltration where feasible. Lacking better geotechnical information, a default (minimum) as recommended in the Highway Runoff Manual, infiltration rate of 0.5 inches per hour was used. This modeling reduced the detention volumes by 42 %, with a corresponding 37% savings in the detention construction costs.

The designers expect that a detailed geotechnical investigation will show that long-term infiltration rates of 1.5 to 3.0 inches per hour are feasible for most of the area. These higher rates will more than halve the current concept detention volumes and costs. However, detention facilities should be designed from a detailed geotechnical investigation (WSDOT Highway Runoff Manual [HRM], Section 4-5).

The HRM criteria involves a detailed geotechnical investigation including sample testing for every strata in bore holes or pits at 100' spacing along infiltration trenches, and one for every 5,000 sq. ft of pond infiltrating surface, plus specific infiltration tests and long term ground water monitoring wells to determine ground water movement/levels through at least one winter season. If left to the design-builder to perform, complying with the long-term ground water monitoring criteria may delay the start of project, as typically drainage work is one of the first things to be designed and installed in a design-build project.

It is proposed that a "concept level" type geotechnical investigation be performed in lieu of a detailed geotechnical investigation. This investigation would provide additional boreholes to supplement existing bore hole logs, perform specific in-situ infiltration tests and install ground water monitoring wells (piezometers). The additional investigation pits/bore holes and infiltration tests provide indications of general infiltration values that the design-build contractor can use for bid costing purposes. The ground water monitoring wells will provide the longer-term observations through one wet season, ready for use when the design-build contracts are awarded. This "concept level" type investigation is sufficient to provide a general indication of ground water patterns and regional infiltration values

After award of the contract, the design-builder will supplement this investigation with additional boreholes/pits/testing. The supplemental geotechnical investigation plan's purpose is to complete the data needed by the design-builder's designers. The supplemental geotechnical investigation will follow the general guidelines contained in the HRM, modified as necessary per the professional judgment of the project geotechnical engineer. Final stormwater treatment, including the infiltration facilities, will be designed using the combined information from the existing borehole logs and results of the concept level and supplemental geotechnical investigations.

Summary

This paper concludes the I-405 Nickel Projects will perform concept level geotechnical investigations.

It is further concluded that the concept drainage design to be included in the I-405 Nickel Projects Request for Proposals (RFP) will include stormwater detention and infiltration facilities based on the default design rate of 0.5 inches per hour. The geotechnical bore hole/pit logs and test data from the concept level geotechnical investigation will be included with the RFP documents for the bidders use in refining the runoff treatment design for bid costing purposes. The long-term ground water monitoring data will be provided by WSDOT to the successful bidder for use in final design and construction, per criteria. The design-builder will be required to perform additional supplemental geotechnical investigations as required by the project geotechnical engineer per the general guidelines of the HRM, for design and construction of functional stormwater infiltration facilities. However, additional long term ground water monitoring is not required by the design-builder.

We based this decision on information we gatherd dealing with three main factors:

- overall benefit to the environment ,
- significant decrease in project costs to follow this approach, and
- improvement of the project schedule.

Decision Basis

Proceeding with a "conceptual level" geotechnical investigation decision for I-405 Nickel Projects was based on the following:

Overall benefit to the environment:

Be able to produce a more refined stormwater runoff treatment design utilizing infiltration to better mimic the natural condition for both treatment through percolating through the soil and maintenance of base flows for streams and wet lands.

Significant decrease in project costs:

Incorporating infiltration into the runoff flow control facility designs will decrease the required detention volumes, reducing and in some cases eliminating the need for the large and expensive concrete vault structures.

Improvement of the project schedule:

The HRM requires that infiltration facility geotechnical investigations include installation of ground water monitoring wells and observations be taken through at least one winter season. It the design-builder is required to meet these criteria, he will not be able to complete the stormwater treatment designs until the following year. The stormwater system is one of the first things to be designed and installed in a typical design-build contract. However, by WSDOT proceeding with the installation and observations of the ground water wells early on in the program, this criteria condition will be completed and available for use by the design-builder expediting design and construction of storm water facilities during the scheduled construction season.

Decision Summary

Each project team within WSDOT has been given the discretion within their project area to make a determination of what approach best fits their circumstances and determines the best path for that specific project. ESO supports this process and ESO has agreed that setting a precedent has not been considered a significant factor for any one project's decision affecting another project's decision

Based on this paper's above discussion, the determination has been made to allow the I-405 Nickel Projects to proceed with implementing a "conceptual level" geotechnical investigation.

Concurring Approvals:

Tony M. Allen   8/13/04

Tony Allen,
WA State Geotech Engineer   Date

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Stormwater Design Decision
Use of "Off-site Inflow Area Option"
To Reduce Flow Control Facility Sizes

March 3, 2005

Washington State
Department of Transportation

Introduction

The purpose of this paper is to formalize and document the decision to use the "Off-site Inflow Area Option" (as provided in Chapter 4 of the Highway Runoff Manual) to improve runoff attenuation characteristics in the project flow control facilities, thus reducing detention volumes.

Background

Previously accepted design criteria for the Kirkland Nickel project assumes a conservative approach for flow control facility sizing. Detention sizes were calculated based on new impervious area only within the respective threshold discharge area, neglecting any additional on-site or off-site flows. This method provides the largest detention volumes because it assumes flow control target discharge rates based on predeveloped forested conditions for the defined subject mitigation area.

WSDOT Highway Runoff Manual, Section 4-3.6 Hydrologic Analysis Methods for Flow Control and Runoff Treatment Facility Design provides for the inclusion of off-site runoff for modeling of flow control facilities when it is not practical to separate off-site and on-site flows. The Off-site Inflow Area Option accounts for the additional off-site inflow "in a way that meets the overall intent of mitigating the effects of increased runoff generated from the project site".

Design criteria outlined in the HRM for the Off-site Inflow Area Option include the following:

- Control of off-site inflow: With this option, flow control is provided for runoff from an upslope area outside the project limits, if the existing 100-year peak flow rate from the off-site inflow area is less than 50% of the 100-year peak flow rate of the on-site mitigation area (for post-developed conditions, without flow control) for the TDA. The control of off-site runoff must be designed to achieve the following:
  - Any existing contribution of flows to a wetland must be maintained.
  - Off-site flows that are naturally attenuated by the TDA under predeveloped conditions should remain attenuated, either by natural means or by implementing additional on-site flow control measures, so the a peak flows do not increase.

The Highway Runoff Manual defines "off-site" as any area lying upstream of the project site that drains onto the site, and/or any area lying downstream of the site to which the site drains. This definition may include areas of highway pavement lying just outside of the project limits, yet still within the WSDOT right-of-way, or areas that are completely outside of the WSDOT right-of-way. WSDOT strongly prefers to separate off-site and on-site runoff because of its inability to control stormwater discharges generated outside of its right-of-way. It is highly preferable to treat (for flow control and water quality) only stormwater runoff that is generated within the right-of-way area.

Threshold discharge area TDA-C has been targetted for this analysis due to the high cost of detention vault storage. Additionally, the subject area is situated in a portion of the freeway corridor where separation of off-site flows (within the right-of-way) is not practical. In this case, acceptance of additional existing freeway pavement to be included for design of the associated flow control facilities is considered beneficial because it maintains the existing flow patterns within the basin, meets the intended downstream levels of flow control protection, and reduces detention vault sizing and related costs.

I-405 design team has proposed flow control designs for TDA-C in two separate facilities. An open pond is proposed at approximate milepost 19.0, and a large closed detention vault to be constructed at approximate milepost 19.4. Preliminary sizing for both of these facilities was based on flow control modeling for equivalent areas of new pavement only, assuming forested predeveloped condition. By using the Off-site Inflow Area Option, flow control may be recalculated to provide a more efficient and cost effective design that meets the intent of the flow control standards.

Summary

Figure 1 illustrates the contributing drainage basins for TDA-C, including on-site mitigation areas, and the targeted "off-site" I-405 mainline pavement area. The contributing off-site inflow area includes a potentially large portion of the freeway, such that the 100-year peak flow rate would be greater than 50% of the 100-year peak flow rate of the on-site mitigation area. Adjustments will be needed for the proposed on-site conveyance system in order to capture the appropriate contributing area.

For this document, off-site inflow area was determined only for the vault portion of TDA-C (not including the pond portion). However, it is assumed that by acceptance of this document, the Off-site Inflow Area Option may be used for all threshold discharge areas in the Kirkland segment where conditions allow. A process for determining the off-site inflow area is provided as follows:

- Step 1 – Determine 100-year peak flow for on-site mitigation area (for post-developed conditions without flow control).
- Step 2 – Determine maximum off-site inflow area that will fit within constraints of design criteria (i.e., 100-yr peak flow for off-site area is less than 50% of 100-year peak flow from on-site mitigation area, assuming off-site inflow area is 100% impervious freeway pavement).
- Step 3 – Adjust proposed conveyance system to capture appropriate catchment area and size the flow control vault based on the adjusted basin (assuming equivalent on-

site mitigation area modeled to forested predevoped conditions, and off-site inflow areas modeled to existing predeveloped conditions).

Based on the steps outlined above, a new vault volume was calculated with the MGS Flood software to be approximately 2.17-acre feet. This is a reduction of approximately 2.43-acre feet (or about 53%) in storage volume from the previously calculated vault.

Decision Basis

Proceeding with the On-site Inflow Area Option for this project is based on the following:

Overall benefit to the environment:
Use of On-site Inflow Area methodology meets the overall intent of mitigating the effects of increased runoff generated from the project site. Use of this method does not reduce the effectiveness or lessen flow control mitigation efforts to protect the downstream environment. Similarly, runoff treatment for water quality will not be affected for freeway runoff (ecology embankments will remain). A stipulation of this method includes that when runoff treatment for water quality is provided in connection with the flow control system, the water quality BMP will be sized to accommodate and treat the additional volume.

Significant decrease in project costs:
By utilizing efficiencies of flow characteristics from the larger basin, detention vault size would be reduced by approximately 50%. Vault size reduction of this magnitude would reduce capital construction cost by approximately $1,000,000.

Decision Summary

Use of the Off-site Inflow Area Option will allow design teams to meet flow control standards, maintain existing basin flow characteristics, and reduce detention facility sizes and associated costs. Where stormwater quality treatment and flow control are combined in the facility, the design team shall provide water quality treatment for the full contributing area.

Concurring Approvals:

Alex Nguyen, WSDOT
Headquarters Hydraulics Div.

3/10/05
Date

Alan Black, I-405 Design Team

3/10/05
Date

ATTACHMENTS:

FIGURE 1 TDA-C DRAINAGE MAP – OFF-SITE INFLOW AREA OPTION

TDA-C VAULT SIZING CALCULATIONS

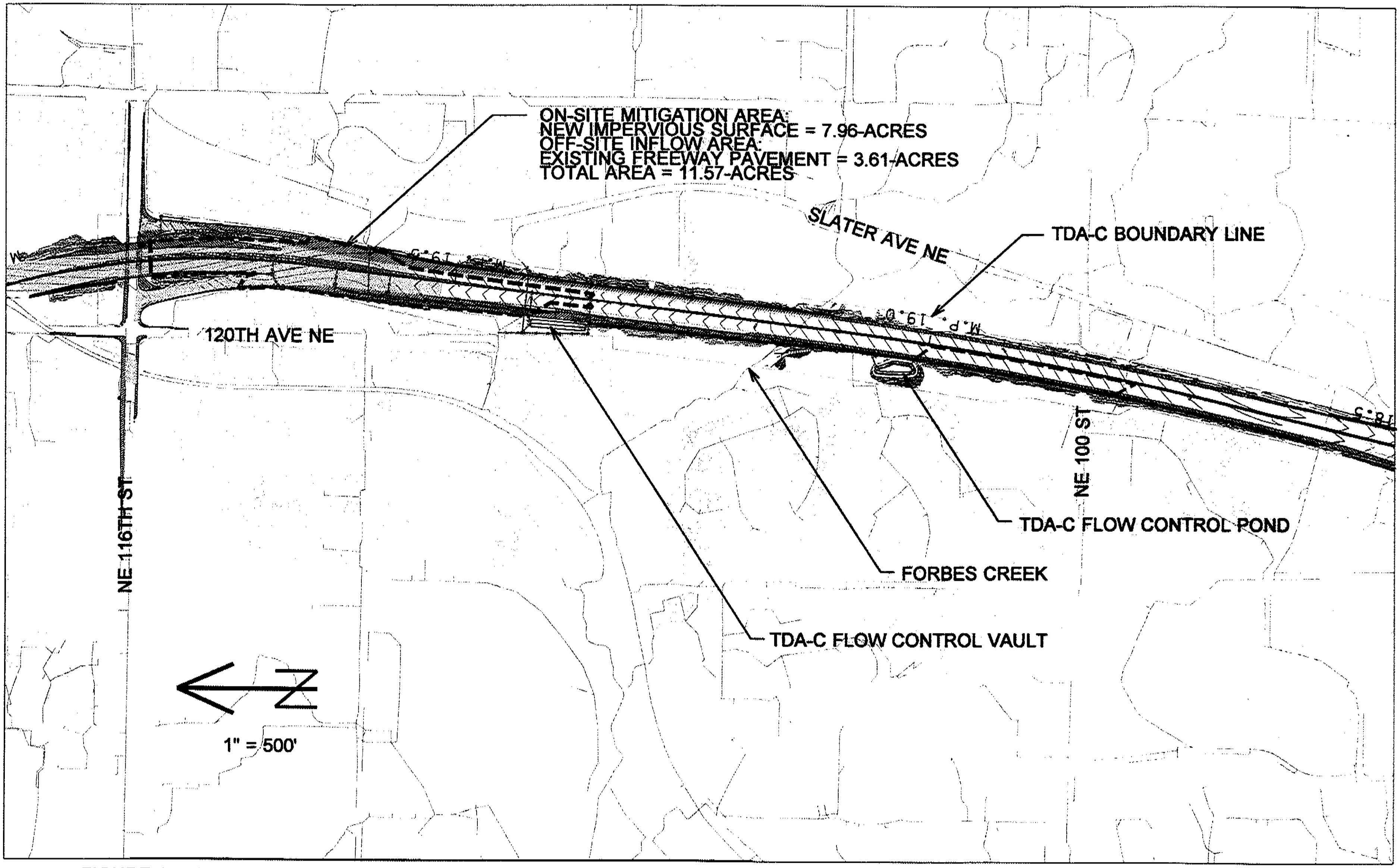

FIGURE 1 TDA-C DRAINAGE MAP; OFF-SITE INFLOW AREA OPTION

TDA-C VAULT SIZING CALCULATIONS

Use Off-site Inflow Area Option to size detention vault in Threshold Discharge Area C

Total Mitigation Area (new impervious surface) in TDA-C

Stage 1 =	6.06-acres
Stage 2 =	3.56-acres
Total =	**9.62-acres**

Mitigation Area treated in TDA-C flow control pond facility = 1.66-acres

Mitigation Area to be treated in flow control vault:

9.62-acres - 1.66-acres = **7.96-acres**

Per Highway Runoff Manual, Section 4-3:

<u>Off-site Inflow Area Option</u>

"With this option, flow control is provided for runoff from an upslope area outside the project limits, if the existing 100-year peak flow rate of the off-site mitigation area is less than 50% of the 100-year peak flow rate of the on-site mitigation area (for post-developed conditions, without flow control) for the TDA".

Freeway conveyance system may be adjusted to regulate the pavement capture area. Determine maximum capture area of freeway pavement:

<u>Step 1:</u>
Calclulate 100-yr peak rate from on-site mitigation area = 7.96-acres

Q100 (on-site) = 4.824-cfs

½ Q100 (on-site) = 2.41-cfs

(See attached file: TDA-C FLOWRATES2.fld)

<u>Step 2:</u>
Calculate maximum area of off-site inflow area (assume 100% impervious surface):

3.9-acres impervious freeway surface will generate a 100-yr peak flow rate

Q100 (off-site) = 2.36-cfs < ½ Q100 (on-site) = 2.41-cfs

(See attached file: TDA-C OFF-SITE FLOWRATES 2.fld)

Step 3:
Calculate detention volume using adjusted "off-site inflow area option" basin:

Maximum freeway pavement area:

Impervious surface < 7.96-acres + 3.9-acres = 11.86-acres

Adjust TDA-C proposed freeway conveyance system to collect and convey pavement area meeting these calculated area parameters.

Adjusted captured pavement area (see Figure 1)

On-site Mitigation Area = 7.96-acres
Off-site Inflow Area = 3.61-acres

Total Area routed to vault = 11.57-ac

Vault sized with MGS Flood software

Volume of Pond at Maximum Elevation = 2.165 ac-ft

(See attached file: TDA-C VOLUME 2.fld)

Assuming 20-ft wide modular vault @ 9-ft storage depth

Vault dimensions are approximately

2-ea @ 262'L x 20'W x 10'D

Different vault configurations possible.

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 02/28/2005 1:29 PM
****

Input File Name: TDA-C FLOWRATES2.fld
Project Name : TDA-C VAULT REDUCTION
Analysis Title: **STEP 1** POST DEVELOPED FLOW RATE
Comments : CALC PEAK FLOW RATES FOR ON-SITE MITIGATION AREA ROUTED TO VAULT

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.000	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	7.960	7.960	0.000	
SUBBASIN TOTAL	7.960	7.960	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	1.547	1.547
2-Year	2.027	2.027
5-Year	2.628	2.628
10-Year	3.079	3.079
25-Year	3.718	3.718
50-Year	4.247	4.247
100-Year	4.824	4.824
200-Year	5.455	5.455

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

****
MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 02/28/2005 1:37 PM
****

Input File Name: TDA-C OFFSITE FLOWRATES 2.fld
Project Name : TDA-C VAULT REDUCTION
Analysis Title: **STEP 2** MAX OFFSITE AREA
Comments : CALC MAX OFFSITE AREA SUCH THAT Q100 IS LESS THAN 2.41-CFS

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------			
		------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	0.000	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	3.900	3.900	0.000	
SUBBASIN TOTAL	3.900	3.900	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)
6-Month	0.758	0.758
2-Year	0.993	0.993
5-Year	1.288	1.288
10-Year	1.509	1.509
25-Year	1.822	1.822
50-Year	2.081	2.081
100-Year	**2.363**	**2.363**
200-Year	2.673	2.673

* Recurrence Interval Computed Using Generalized Extreme Value Distribution

****

MGS FLOOD
PROJECT REPORT

Program Version: 2.2.5 Run Date: 02/28/2005 2:57 PM

****

Input File Name: TDA-C VOLUME 2.fld
Project Name : TDA-C VAULT REDUCTION
Analysis Title: **STEP 3** CALCULATE DETENTION VOLUME
Comments : DETENTION VAULT SIZING CALC USING OFFSITE IN-FLOW AREA OPTION

Extended Timeseries Selected
Climatic Region Number: 11

Full Period of Record Available used for Routing
Precipitation Station : 960040 Puget East 40 in MAP 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) ***************

********** Watershed Definition **********
Number of Subbasins: 1

********** Subbasin Number: 1 **********
***Tributary to Node: 1
***Bypass to Node : None

	---------Area(Acres) -------------	------Developed-----		
	Predeveloped	To Node	Bypass Node	Include GW
Till Forest	7.960	0.000	0.000	No
Till Pasture	0.000	0.000	0.000	No
Till Grass	0.000	0.000	0.000	No
Outwash Forest	0.000	0.000	0.000	No
Outwash Pasture	0.000	0.000	0.000	No
Outwash Grass	0.000	0.000	0.000	No
Wetland	0.000	0.000	0.000	No
Impervious	3.610	11.570	0.000	
SUBBASIN TOTAL	11.570	11.570	0.000	

*** Subbasin Connection Summary ***
Subbasin 1 --------------> Node 1

*** By-Pass Area Connection Summary ***
No By-Passed Areas in Watershed

Pond Inflow Node : 1
Pond Outflow Node: 99

********** Retention/Detention Facility Summary **********

Hydraulic Structures Add-in Routines Used
----------------- Pond Geometry -----------------

Prismatic Pond Option Used

Pond Floor Elevation : 100.00 ft
Riser Crest Elevation : 109.00 ft
Maximum Pond Elevation : 109.50 ft
Maximum Storage Depth : 9.00 ft
Pond Bottom Length : 498.1 ft
Pond Bottom Width : 19.9 ft
Side Slope : 0.00 ft/ft
Infiltration Rate : 0.00 in/hr
Pond Bottom Area : 9926. sq-ft
Area at Riser Crest El : 9926. sq-ft
: 0.228 acres
Volume at Riser Crest : 89330. cu-ft
: **2.051 ac-ft**
Area at Max Elevation : 9926. sq-ft
: 0.228 acres
Volume at Max Elevation: 94293. cu-ft
: **2.165 ac-ft**

----------------- Riser Geometry -----------------
Riser Structure Type : Circular
Riser Diameter : 18.00 in
Common Length : 0.028 ft
Riser Crest Elevation : 109.00 ft

---------- Hydraulic Structure Geometry -----------

Number of Devices: 3

--- Device Number 1 ---
Device Type : Circular Orifice
Invert Elevation : 100.00 ft
Diameter : 3.09 in
Orientation : Horizontal
Elbow : No

--- Device Number 2 ---

Device Type : Vertical Rectangular Orifice
Invert Elevation : 103.84 ft
Length : 0.3 in
Height : 61.9 in
Orientation : Vertical
Elbow : No

************** Flow Frequency Data for Selected Recurrence Intervals *************

Tr (Years)	Subbasin 1 Runoff Predevelopment* Flow(cfs)	Subbasin 1 Runoff Postdevelopment* Flow(cfs)	Pond Outflow Node Postdevelopment** Flow(cfs)
6-Month	0.757	2.248	
2-Year	1.017	2.947	0.582
5-Year	1.343	3.820	0.860
10-Year	1.588	4.476	1.024
25-Year	1.938	5.404	1.484
50-Year	2.228	6.173	1.537
100-Year	2.546	7.012	1.779
200-Year	2.895	7.929	2.699

* Recurrence Interval Computed Using Generalized Extreme Value Distribution
** Computed Using Gringorten Plotting Position

**** Flow Duration Performance According to Dept. of Ecology Criteria ****
Excursion at Predeveloped ½Q2 (Must be Less Than 0%): -11.5% PASS
Maximum Excursion from ½Q2 to Q2 (Must be Less Than 0%): -10.7% PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%): 6.5% PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%): 5.9% PASS

****
* POND MEETS ALL DURATION DESIGN CRITERIA: PASS
****

******************* Water Quality Facility Data ***************

Basic Wet Pond Volume (91% Exceedance): 50114. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 75171. cu-ft
2-Year Stormwater Pond Discharge Rate: 0.582 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
Discharge Rates Computed for Node: 1
On-line Design Discharge Rate (91% Exceedance): 0.00 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.00 cfs

****

APPENDIX E

FISH PASSAGE IMPROVEMENTS

Forbes Creek Fish Passage Design Data Summary Form

SECTION 1: GENERAL

PROJECT

Stream name: **Forbes Creek**
WRIA: **WRIA 08 Cedar-Sammamish**
Tributary to: **Lake Washington**
Name of road crossing & Mile Post: **I-405 located approximately at MP 19.1**
Road owner: **Washington Department of Transportation**
USGS QUAD Map: **Bellevue North, Washington, 7.5 X 15 minute quadrangle, 1982**
SECTION **33** TOWNSHIP **26N** RANGE **5E**
Project Owner: **Washington Department of Transportation**
Designer: **HDR**
Contact (phone, email): **Matthew Gray, PE, Phone: 425.450.6232, Email: matthew.gray@hdrinc.com**

Brief Narrative of Project:

Forbes Creek drainage basin is approximately 2227.5 acres in size with approximately 915 acres upstream of the I-405 culvert. The head of the basin drains into Forbes Lake which discharges through Forbes Creek into Lake Washington approximately 2.1 miles downstream. The basin is within the City of Kirkland municipal limits. The creek is primarily located within park/open space and low-density residential land use areas.

Historically the creek has supported cutthroat trout populations and according to Municipality of Metropolitan Seattle's Quality of Local Lakes and Streams 1988 - 1989 Status Report Metro (1990) coho salmon have been introduced. In 2001, King County Water and Land Resources Division's Volunteer Salmon Watcher Program reported one coho observed in the creek.

Restoration potential above the I-405 culvert is limited to the physical length of the stream, about 2500 feet above I-405. The estimated maximum capacity of the upstream reach is 24 adult salmon with an average return of five to ten salmonids a year.

The proposed expansion of I-405 has triggered an assessment of the existing culvert which has been determined to be a fish passage barrier.

Who will likely perform the design work? **HDR has performed preliminary design. An awarded Design/Build Contractor will complete design.**

Has WDFW provided design assistance or consultation regarding this design option? **Yes**
If yes, who was the WDFW contact? **Pat Klavas**
Who will likely perform the construction work? **An awarded Design/Build Contractor will perform construction.**

FISH

Species of fish likely to be present and any special passage requirements: **Cutthroat trout, coho**

HYDROLOGY

	Q7L2	Q2	Q100
Current Watershed Conditions	**0** cfs	**21** cfs	**86** cfs
Future Watershed Conditions	**0** cfs	**103** cfs	**305** cfs

(From June 2nd Memo)

Contributing Watershed Area: **1.43 mi^2 (915 acres)**
Mean Annual Precipitation: **42 inches**
2-Year 24-Hour Precipitation: **0.20 inches**

UPSTREAM CHANNEL

Upstream channel length: **2500 ft** *(From June 2nd Memo)*
Upstream channel slope: **0.03 ft/ft** *(From Survey Data Supplied on 7/23)*

Bankfull width: **Approximately 12 feet**
Bankfull depth: **Approximately 9 to 12 inches**
Floodplain width: **Will need to be verified during the final design.**

Stream bed material type and the basis of vertical control (wood or rock dominated):**Estimated 6" – 9" diameter substrate with quite a bit of fines. Stream bed materials should be confirmed during final design of the new culvert.**

Stream bed size distribution: D100________ D84_________ D50________ D16_________

Is there evidence of a significant amount of bed material transport? **Yes, Deposition of fines**
Is the channel in equilibrium (not aggrading or degrading)? **Yes**
Is there a significant amount of mobile woody debris present? **No**
Are there structures in the bed or channel that could be exposed or undermined by upstream channel regrade? **There is a chain link fence located immediately upstream of the culvert. A full examination of structures located up stream of the Right-Of-Way limit has not been conducted at this time. The final design will need to address this issue in greater detail.**
Additional upstream information, other conditions or concerns : **Concerned with minimum flow depths upstream of the culvert as a result of the grading that will be required for the new culvert inlet bed elevation.**

DOWNSTREAM CHANNEL

Elevation of stream bed at downstream control point: **195.57 feet (approximately 25 feet downstream of culvert apron (From field survey performed by APS Survey & Mapping).**
Downstream channel slope: **Approximately 0.05 ft/ft**
Bankfull Width: **15 – 18.5 feet**
Bankfull Depth: **Approximately 1 foot**
Streambed Material type: **Mostly 9" – 12" diameter substrate with larger boulders and fines. Stream bed materials should be confirmed during final design of the new culvert.**
Floodplain Width: **Will need to be verified during the final design.**
Manning's "N" for the downstream channel: **0.04**
Channel Capacity: **From Manning's equation, channel capacity is approximately 130 cfs, but needs to be verified upon final design.**

Are there structures in the bed or channel that could be affected by design? **None noted immediately downstream of the culvert.**

Additional Information

Describe any existing or proposed structures or natural features that would affect fish passage, interfere with compliance with regulations, or compromise habitat considerations. Examples of this include trash racks, sediment basins, stormwater control devices, existing up- or downstream barrier culverts, or bedrock chutes.

A metal apron is currently located at the downstream end of the existing culvert. Another culvert approximately 300 feet in length is located approximately 850 feet downstream. This culvert is located under the Airshow property and discharges onto a rock pile approximately 8 - 12 feet below in the outlet. The Airshow culvert is probably a barrier to passage. It is understood that the rock was placed under emergency actions. Additional barriers downstream of Airshow have been identified as well.

SECTION 2: CULVERT DESIGN

(To be filled out, in addition to SECTION 1, by applicants using the WDFW NO-SLOPE or STREAM SIMULATION Method described in the WDFW publication *Fish Passage at Road Crossings* and WAC 220-110-070)

This section does not apply, as the Hydraulic Design Method has been used, see Section 3.

	Existing	Proposed
Shape:		
Material:		
Rise:		
Span:		
Upstream Invert Elevation:		
Downstream Invert Elevation:		
Length:		
Slope:		
Culvert Countersink (Upstream):		
Culvert Bed Width (Upstream):		
Culvert Countersink (Downstream):		
Culvert Bed Width (Downstream):		
Culvert skew angle to stream:		
Slope Ratio (chan. slope/culv. Slope)		
Height of Road fill		

Bed Material within Culvert: (Natural or imported, D100, D84, D50 and D16 if available or verbal characterization: "9 inch minus well-graded river rock")

How is Imported Bed Material Designed for Stability?

Are grade controls necessary? (If yes fill in channel reconstruction section)
Distance of first upstream control from inlet of culvert:
Distance of first downstream control from outlet of culvert:

SECTION 3: HYDRAULIC DESIGN (To be filled out, in addition to SECTION 1, by applicants designing a Culvert or a Fishway using the Hydraulic method described in the WDFW publication *Fish Passage at Road Crossings* and WAC 220-110-070)

PART A: GENERAL

Species of Migratory Fish and Migration Timing:

	Present (Y,N)	Timing Month(s)
Adult Coho, Sockeye Salmon	**Yes**	**09/15 thru 01/01**
Adult Pink or Chum Salmon		
Adult Trout:	**Yes**	**All year**
Juvenile Salmon, Steelhead, or Trout		

Source of information:
Personal Communication with Paul LaRaiviere (Fish Biologist, HDR) and Pat Klavas (WDFW).

ESTIMATED FISH PASSAGE FLOWS

	Current Watershed (Qfp)	Future Watershed (Qfp)
Adult Coho, Sockeye		**0 (Q_{lfp}) – 18 (Q_{hfp}) cfs**
Adult Pink, Chum		
Adult Trout		**0 (Q_{lfp}) – 18 (Q_{hfp}) cfs**
Juvenile Salmon, Steelhead, Trout		

Describe how flows were estimated and assumptions of future conditions:
Q_{lfp} is based upon 2 year, 7 day low flow discharge analysis from continuous time series model (MGS Flood), and the Q_{hfp} is based upon WDFW regional regression equations for lowland streams in January with standard error applied, as accepted by Pat Klavas of WDFW.

PART B: CULVERT (To be filled out, in addition to SECTION 1 and SECTION 3A, by applicants designing a Culvert using the Hydraulic method described in the WDFW publication *Fish Passage at Road Crossings* and WAC 220-110-070)

Maximum water velocity (fps) in culvert at fish passage design flows (Qfp)

	Design Velocity (Current)	Design Velocity (Future)	Velocity Allowable (WAC)
Adult Coho, Sockeye	**6.21 ft/sec**	**2 ft/sec**	**3 ft/sec**
Adult Pink, Chum			
Adult Trout	**6.21 ft/sec**	**2 ft/sec**	**2 ft/sec**
Juvenile Salmon, Steelhead, Trout			

Describe how velocities were calculated:

Design Velocity for the existing culvert was calculated using FlowMaster with the following parameters:

Mannings n = 0.024 (CMP)
Slope = 0.017
Diameter = 42 inches
Qhfp = 18 cfs

Velocity in the existing 42" CMP at 18 cfs exceeds criteria, necessitating culvert replacement or the addition of another culvert designed to meet criteria.

Design velocity for the new culvert is based on the allowable velocity for the species indicated as denoted in Table 1 of WAC 220-110-070 based on a culvert length greater than 200 feet.

WATER SURFACE ELEVATIONS

Upstream of Culvert

Q_{100} **elev. 213.6 @ 305 cfs**
Hw/D (Q_{100}) **2.0 for existing 42" CMP, 1.5 for new 78" Steel**

Is culvert under Inlet or Outlet Control? (Q_{100}) **Calculations indicate that both culverts are under Outlet Control at Q_{100}.**

Downstream of Culvert

Q_{7L2} **205.54 ft (corresponds to the fishway weir crest immediately downstream of the new 78" culvert)**
OHW **Not applicable, because both culverts outlets are too high to be affected by OHW in the downstream channel. Water surface elevation for OHW in the channel downstream of the fishway needs to be verified in final design.**

Describe how water surface elevations were determined. **Up stream water surface elevations were determined by calculating the inlet and outlet control water surfaces associated with the two culverts. The distribution of Q_{100} flow between the two culverts was determined by trial and error until the upstream water surface for the two culverts matched based on the inlet/outlet control assessment for the flows assigned to each pipe. The Q_{7L2} down stream water surface is a zero flow condition determined by the fishway weir immediately downstream of the new 78" culvert.**

	Existing	Proposed
Shape:	**Circular**	**Circular**
Material:	**CMP**	**Steel Pipe**
Rise:	**42 inches**	**78 inches**
Span:	**42 inches**	**78 inches**
Upstream Invert Elevation:	**206.54 ft**	**203.49 ft**
Downstream Invert Elevation:	**198.82 ft**	**202.79 ft**
Length:	**453 feet**	**440 ft**
Slope:	**0.0170 ft/ft**	**0.0016 ft/ft**
Culvert Countersink (Upstream):	**0.25 ft**	**1.3 ft**
Culvert Bed Width (Upstream):	**1.66 ft**	**5.2 ft**
Culvert Countersink (Downstream):	**0 ft**	**1.3 ft**
Culvert Bed Width (Downstream):	**0 ft**	**5.2 ft**
Culvert skew angle to stream:	**0 deg**	**0 deg**
Slope Ratio (chan. slope/culv. Slope)		
d/s channel slope / culvert slope	**2.94**	**31.25**
u/s channel slope / culvert slope	**1.76**	**18.75**
Height of Road fill	**30 feet**	**30 feet**

Note: The current preliminary design calls for leaving the existing 42" CMP in place for flood flow capacity.

Proposed culvert bed treatment at upstream end: **To be determined in final design**
Baffles: **No**
If yes, baffle size, shape, and spacing: **Not Applicable**
Streambed Retention Sills: **No**
If yes, Streambed Retention Sills size, shape, drop at each structure, spacing: **Because the distance of the existing Right-of-Way boundary to the up stream end of the culvert is less than 30 ft, regrading the channel up stream of the new culvert may be required to meet agency criteria. The upstream channel grading will need to be addressed during final design.**

Bed Material Within Culvert: (Natural or imported, D100, D84, D50 and D16 if available or descriptive characterization: "9 inch minus well-graded river rock")
Import will be similar to natural (9" – 12" diameter substrate with larger boulders and fines). Sizing will need to be verified during the final design.

How is Imported Bed Material Designed for Stability?
Culvert bed material will need to be designed, per WDFW Design of Road Culverts for Fish Passage beginning on page 33, during the final design.

Are grade controls necessary? (If yes fill in Channel Reconstruction Section) **Possibly. Because the distance of the existing Right-of-Way boundary to the up stream end of the culvert is less than 30 ft, regrading the channel up stream of the new culvert may be required to meet agency criteria. The upstream channel grading will need to be addressed during final design.**

State distance of first upstream control from inlet of culvert: **To be determined in final design.**
State distance of first downstream control from outlet of culvert: **10 ft (to overflow weir at fishway forebay).**

PART C: FISHWAY (To be filled out, in addition to SECTION 1 and SECTION 3A, by applicants designing a Fishway (formal concrete fishway) using methods described in WDFW manual *Fishway Design for Pacific Salmon.* For fishways using log controls or other grade controls structures, use to SECTION 5 instead of this section.)

Type (pool/weir, vertical slot, etc) **Pool / Weir**
Dimensions of Pools: Length **8.0** ft Width **8.0** (+/-) ft Depth **3.4** ft
Total Vertical change to be made up by fishway **9.75** ft
Vertical Drop between pools: **0.75** (+/-) ft
Weir or slot Coefficient of C: Slot: __________, or Weir: **3.43 & 3.70 (C = 3.22 + 0.4H/P, where H = head on weir & P = upstream depth from top of weir to floor)**

Make a table for the following information at low flow and high flow:
Fishway flow:
Downstream water surface elevation:
Upstream water surface elevation:
Energy dissipation factor:

Flow Condition	Q (cfs)	Water Surface Elevation		EDF
		Downstream	Upstream	
High FP Flow	18	196.54	206.29	3.9
Low FP Flow	0	195.79	205.54	N/A

Note: Minimum pool depth of 2.65 ft for no-flow condition.

Describe method of fishway flow control:
The fishway is designed for a minimum fish passage flow of 0 cfs. This requires each pool to not drain, except during maintenance operations when a manual knife gate (or similar control) will be pulled in each pool, thus allowing the water to drain. The fishway is designed to pass 18 cfs over the entire 8 (+/-) foot span of weir with a head of 0.8 ft. At 18 cfs, the overflow weir located at the upstream end of the fishway will have approximately 1 ft of freeboard. Therefore, as flow increases above 18 cfs, the fishway will continue to pass all flow until approximately 70 cfs when the overflow weir will begin to pass flow directly to the stream below. Weir length of the overflow weir is 19 ft.

It should be noted that WDFW suggested using a wide angled V-weir (8' wide with a 6" rise) rather than a rectangular weir configuration for the fishway weirs. The V-weir configuration was not incorporated into this 30% design, and will need to be addressed with WDFW during the final design phase due to its significant effect on the fishway flow characteristics.

Describe geometry of fishway entrance and spillway, if present.
The fishway entrance is located directly adjacent to the overflow weir as shown on the drawings. However, it should be noted that the overflow weir will not pass water throughout the entire range of fish passage flows.

Based on bed material and debris expected, describe expected operation and maintenance:
Periodic inspection of the fishway will be required, but debris loading is expected to be low. During maintenance operations, each pool will have a knife gate (or similar control) that can be opened to allow draining for maintenance. Regular periodic inspection of all the pools for debris accumulation will be required.

Additional Fishway information, or other conditions or concerns:
____
____

SECTION 4: BRIDGE (To be filled out, in addition to SECTION 1 and SECTION 5, by applicants designing a Bridge described in WAC 220-110-070)

Bridge Span: ______________________________ ft
Channel bed width under bridge______________________________ ft
Embankment Side slopes under bridge ______________________________ h:v
Height from channel bottom to bottom of bridge deck ______________________________ ft
Abutment type and material______________________________ ft
Distance from channel centerline to abutment______________________________
Bridge Skew Angle to Stream: ______________________________ deg
Slope Ratio (constructed channel slope/upstream channel slope):______________________________
Are grade controls necessary? (If yes see Channel Reconstruction Section)? Y N
____

Additional Bridge information, or other conditions or concerns
____
____
____

SECTION 5: CHANNEL RECONSTRUCTION ((To be filled out, in addition to SECTION 1, by applicants designing or performing channel work in conjunction with or separate from other channel structures, bridges, culvert removal road abandonment, or channel modification)

Is this work in conjunction with other structures in the channel (culvert, fishway, bridge)?
Proposed grade controls: (type)
Material of controls:
Number of controls:
Total Vertical change to be made up by structures:
Drop between successive controls:
Control width:
Channel Bankfull width:
Spacing between controls:
Stream bed size distribution: D100_________ D84__________ D50_________ D16__________
Slope Ratio (constructed channel slope/upstream channel slope):______________________________

Large Woody Debris (LWD) Being Placed as a part of a fish passage design?
LWD Size? Diameter _____________ft Length _____________ft
Number of logs/unit ____
Function of LWD ____
Location of LWD in Channel ____
Elevation of LWD with respect to Bankfull Width ____
Is the LWD Anchored? Or Mobile? ____
If anchored, Depth of Embedment is ___________________ft Weight of Anchors _______________lbs
Number of Anchors ____

Additional Channel information, or other conditions or concerns

____
____
____

Job No.	15124	Calc No.	00001

Computation

FISHPRO
A DIVISION OF HDR

Project	I-405 Congestion Relief & Bus Rapid Transit Project	Computed	Mark Hassebrock
System	Modification to existing drainage system on Forbes Creek	Date	11/17/2004
Component	Forbes Creek Culvert Replacement	Reviewed	John D. Nelson
Task	Design Culvert Replacement and allowable drops to pass Cutthroat Trout	Date	11/30/2004

Purpose

Evaluate existing 42" dia. CMP and consider new culvert for Forbes Creek flowing under I-405.

Existing Culvert:

42" diameter CMP

453 ft long at approximate 0.0170 ft/ft slope

From 1-ft contour map provided by APS Survey & Mapping 425.427.2554

Summary

Design Criteria & Assumptions

References

1 Stormwater Design Criteria for I-405 Corridor, dated May 18, 2004
2 WDF&W Fish Passage Design at Road Culverts, 2003 Edition.
3 WSDOT Hydraulics Manual, M23-03, March, 2004
4 Hydrology and Hydraulic Design Methodology for Forbes Creek Culvert, Matt Gray Memo, July 21, 2004
   * Flow rates (25-yr, 100-yr, low fish passage flow and high fish passage flow) were obtained from this document *
5 Preliminary Sizing of Forbes Creek Culvert Under I-405, Matt Gray Memo, June 2, 2004
   * Existing Culvert Information was obtained from this document *
6 Existing culvert will remain in place along with new culvert to optimize flood flow performance.

Fish Passage Flow Rate Criteria for Resident Cutthroat Trout

Minimum culvert flow rate for fish passage

Design minimum fish passage for 0 cfs with minimum flow depth of 0.75 ft.

Maximum culvert flow rate for fish passage

Q_{fp} = 18 cfs with maximum velocity of 2 fps.

[reference WDF&W Fish Passage Design at Road Culverts , Table 5-1, relative to adult trout and culvert length greater that 200 ft.]

Maximum Culvert Capacity and Maximum Headwater Criteria

100-yr flow is 305 cfs with no overtopping the roadway

Allowable Headwater (HW) = (1.25xD) @ 25-yr flow of 220 cfs

Note that the D measurement is from the invert of the stream bed at the inlet of the culvert assuming that 20%of the diameter is buried.

[reference WSDOT Hydraulics Manual]

Maximum allowable water surface drop (pool to pool) = 0.80 ft.

[reference: WDF&W Fish Passage Design at Road Culverts, Table 5-1, relative to adult trout]

Solution

CHECK CRITERIA COMPLIANCE OF EXISTING CONDITION

25-year flow (220 cfs) in 42" CMP exceeds allowable headwater criterion of HW/D not to exceed 1.25

(per inlet control nomograph for projecting CMP entrance)

No need to check outlet control case because highest water surface is assumed to control.

CALCULATE HEADWATER ELEVATIONS OF THE TWO-CULVERT SYSTEM

100-Year Flow Conditions (Streamflow = 305 cfs)

Note: The 78" Steel culvert will have 1.3 ft of bed material. ***All hydraulic calculations on the 78" Steel culvert have been run based on a slightly smaller pipe (73" diameter) with equivalent open area.***

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Computation

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Start by assuming that both culverts operate under Outlet Control
Use equation for calculating head under OC flow conditions:

$$H = \left\{ \frac{2.5204(1+ke)}{D^4} + \frac{466.18n^2L}{D^{16/3}} \right\} \times (Q/10)^2$$

Reference: Handbook of Concrete Culvert Pipe Hydraulics, App. C, Portland Cement Association 1964

Applying this equation simultaneously to both culverts allows manipulation of the flow split between the two culverts while observing the upstream water surface associated with the flow assigned to each one. The flow split was adjusted until the upstream water surface elevations matched (see 100-Year Outlet Control Calculation attached). The following upstream water surfaces were generated:

42" CMP: Flow = 80 cfs, Upstream WSE = 213.6
78" Steel: Flow = 225 cfs, Upstream WSE = 213.7
(Total flow = 80 + 225 = 305 cfs)

For both culverts, the discharge condition was assumed to be at the top of the pipe (full flow, most conservative case). The 42" CMP discharges freely to the channel below, so there is no potential for backwater above the top of the pipe. The 78" Steel discharges to to the new fishway, which could generate a water surface higher than the top of pipe at the discharge end. Hydraulics of the fishway forebay were examined to determine the water surface elevation at 225 cfs, which is the portion of the 100 year flow in the 78" Steel. The attached 100-Year Fishway Head Pool calculation and 100-Year Submerged Weir calculation show a calculated fishway forebay water surface of 209.0, which is less than the elevation at the top of the 78" Steel (209.3). Therefore the fishway forebay water surface will not increase the OC WSE of the 78" Steel pipe.

Now check Inlet Control for both culverts at the flow rates identified for each one to verify that they are both under Outlet Control. Nomographs for Inlet Control from Handbook of Concrete Culvert Pipe Hydraulics, App. B were used, with inlet configurations corresponding to the stated OC flow conditions used in the OC calculation.

42" CMP at 80 cfs:
HW/D = 1.5 (from nomograph)
HW = 1.5(3.5 ft) = 5.3 ft
Upstream invert elevation = 206.5
Upstream WSE = 206.5 + 5.3 = 211.8 <== IC WSE is less than OC WSE, therefore culvert is outlet controlled.

78" Steel at 225 cfs:
HW/D = 1.0 (from nomograph)
HW = 1.0(6.1 ft) = 6.1 ft
Upstream invert elevation = 204.8
Upstream WSE = 204.8 + 6.1 = 210.9 <== IC WSE is less than OC WSE, therefore culvert is outlet controlled.

Results of IC check confirm that both culverts are outlet controlled, therefore the OC WSE calculated above controls, and the 100-year HW/D for each culvert is:

42" CMP: HW/D = 7.1/3.5 = 2.0
78" Steel: HW/D = 8.9/6.1 = 1.5

Job No.	15124	Calc No.	00001

Computation

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Project	I-405 Congestion Relief & Bus Rapid Transit Project	Computed	Mark Hassebrock
System	Modification to existing drainage system on Forbes Creek	Date	11/17/2004
Component	Forbes Creek Culvert Replacement	Reviewed	John D. Nelson
Task	Design Culvert Replacement and allowable drops to pass Cutthroat Trout	Date	11/30/2004

25-Year Flow Conditions (Streamflow = 220 cfs)

At the 100-year flow condition both pipes were close inlet control, so start by assuming both pipes are under inlet control for the 25-year flow.

Nomographs for Inlet Control from Handbook of Concrete Culvert Pipe Hydraulics, App. B were used, with the same inlet configurations as before. Trial flow splits between the two culverts were checked until the following split was obtained:

42" CMP at 55 cfs:

HW/D = 1.0 (from nomograph)
HW = 1.0(3.5 ft) = 3.5 ft
Upstream invert elevation = 206.5
Upstream WSE = 206.5 + 3.5 = 210.0

78" Steel at 165 cfs:

HW/D = 0.8 (from nomograph)
HW = 0.8(6.1 ft) = 4.9 ft
Upstream invert elevation = 204.8
Upstream WSE = 204.8 + 4.9 = 209.7

Note: For purposes of this calculation, invert elevation is considered equivalent to bed material surface as shown on drawing.

Now check Outlet Control for both culverts at the flow rates identified for each one to verify that they are both under Inlet Control.

42" CMP at 55 cfs: Used FlowMaster to check for pipe-full flow

FlowMaster Input values:

n = .024
Slope = 0.017
Diameter = 42 inches
Discharge = 55 cfs

Normal depth calculated as 2.3 ft, flow is supercritical, and downstream water surface is below water surface in barrel, therefore the pipe is inlet controlled.

78" Steel at 165 cfs: Used equation for calculating head under OC flow conditions as with 100-year calculation (see 25-year Outlet Control Calculation and fishway forebay pool calculations attached).

Flow = 165 cfs, Upstream WSE = 210.5 <== OC WSE is greater than IC WSE, therefore culvert is outlet controlled, but the indicated WSE is still close enough to the calculated WSE for the 42" CMP to call it good.

The 25-year HW/D for each culvert is:

42" CMP: HW/D = 1.0 (from IC nomograph)
78" Steel: HW = 5.7/6.1 = 0.9

Both values meet the WSDOT criterion of HW/D < 1.25.

Job No. 15124	Calc No. 00001

Computation

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Project	I-405 Congestion Relief & Bus Rapid Transit Project	Computed	Mark Hassebrock
System	Modification to existing drainage system on Forbes Creek	Date	11/17/2004
Component	Forbes Creek Culvert Replacement	Reviewed	John D. Nelson
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CALCULATE DEPTH OF HEAD FOR HORIZONTAL CRESTED RECTANGULAR WEIR

First calculate required pool depth:

Pool Volume = 62.4 * Q * Head / 4 (EDF)

Pool Volume = 62.4 * 18 * 0.75/4 = 210.6 ft^3

Dimensions of fishway step pools are 8' wide by 8' long, thus required depth = 210.6 cf / 64sf = 3.3' at 18 cfs

Assume Horizontal Crested Weir for this design.

$Q = CLH^{3/2}$ [reference Handbook of Hydraulics, Brater and King, 6th Edition, Chapter 3]

where
- Q = flow rate in cfs
- C = 3.22 + 0.4(H/P)
- L = width of sharp crested weir in feet (8' for this design as an initial assumption, see note on page 4 of 5)
- H = head on weir in feet (design for 0.75' drop)
- P = height of weir crest above floor

Note: WDFW has expressed a preference for V-shaped weirs, but this would have a significant impact on the required width of the weirs to maintain the step-height criterion. Further investigation into options regarding weir shape to optimize low flow conditions needs to be conducted in final design.

Weir calculation at fishway forebay pool:

		Head Height		Weir Height		Total
Q (cfs)	C	H (ft.)	H (in.)	P (ft.)	P (in.)	height (ft.)
18.0	3.43	0.75	9.05	1.45	17.40	2.20
					pool floor elev. =	204.09
					water surface elev. =	206.29

Weir calculation at pools 1 - 13

		Head Height		Weir Height		Total
Q (cfs)	C	H (ft.)	H (in.)	P (ft.)	P (in.)	height (ft.)
18.0	3.33	0.75	9.05	2.65	31.80	3.40

Note: Greater weir height at pools 1 - 13 results in a slightly smaller C value. To maintain H = 0.75 requires a weir length of 8.25 ft. It is anticipated that further refinement of the final weir configuration will be required in final design as noted above to optimize low flow conditions.

Job No.	15124	Calc No.	00001

Computation

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Project	I-405 Congestion Relief & Bus Rapid Transit Project	Computed	Mark Hassebrock
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CALCULATE EACH POOL WATER SURFACE ELEVATION AND POOL DEPTH

			Low Fish Passage Flow (0 cfs)		High Fish Passage Flow (18 cfs)	
Location	Invert Elev.	Weir Crest	Water Surface	Water Depth	Water Surface	Water Depth
US end of 78" pipe	204.79		205.54	0.75	206.44	1.65
fishway forebay	204.09	205.54	205.54	1.45	206.29	2.20
pool #1	202.14	204.79	204.79	2.65	205.54	3.40
pool #2	201.39	204.04	204.04	2.65	204.79	3.40
pool #3	200.64	203.29	203.29	2.65	204.04	3.40
pool #4	199.89	202.54	202.54	2.65	203.29	3.40
pool #5	199.14	201.79	201.79	2.65	202.54	3.40
pool #6	198.39	201.04	201.04	2.65	201.79	3.40
pool #7	197.64	200.29	200.29	2.65	201.04	3.40
pool #8	196.89	199.54	199.54	2.65	200.29	3.40
pool #9	196.14	198.79	198.79	2.65	199.54	3.40
pool #10	195.39	198.04	198.04	2.65	198.79	3.40
pool #11	194.64	197.29	197.29	2.65	198.04	3.40
pool #12	193.89	196.54	196.54	2.65	197.29	3.40
pool #13	193.14	195.79	195.79	2.65	196.54	3.40
Forbes Creek Bed	193.10		195.0	1.90	195.8	2.70

Notes:

1. Forbes Creek bed elevation at downstream end of fishway will need to be excavated to provide adequate depth for fish to approach and make the first leap into the fishway.
2. Creek water surface near fishway entrance is approximately 195.0 at low fish passage flow and 195.8 at high fish passage flow (needs to be verified in final design).

Fishway dimensions

Pools are 8.25' wide by 8' long

Location	Weir Crest	Pool Floor Elev.	Approx. Wall El.
fishway forebay	205.54	204.09	209
pool #1	204.79	202.14	209
pool #2	204.04	201.39	208
pool #3	203.29	200.64	207
pool #4	202.54	199.89	206
pool #5	201.79	199.14	206
pool #6	201.04	198.39	205
pool #7	200.29	197.64	204
pool #8	199.54	196.89	203
pool #9	198.79	196.14	203
pool #10	198.04	195.39	202
pool #11	197.29	194.64	201
pool #12	196.54	193.89	200
pool #13	195.79	193.14	200

Forbes Creek Fishway
100-Year Outlet Control Calculation

Qtotal	305 cfs	

42" culvert

Q	80 cfs	
D	3.5 ft	
n	0.024	(CMP)
Ke	0.43	(Headwall with square-edged entrance)
L	453 ft	
So	0.017	
ho	3.5 ft	(Top of pipe)
upstream IE	206.5	
H	11.3 ft	
HW	7.1 ft	
WSE	213.6	

78" culvert

Q	225 cfs	
D	6.1 ft	(Adjusted culvert size to account for bed fill, equivalent flow area)
n	0.018	(Composite n for steel and streambed material)
Ke	0.35	(Headwall with square-edged entrance and 45-degree wingwalls)
L	440 ft	
So	0.0016	
ho	6.1 ft	(Top of pipe)
upstream IE	204.8	(For purposes of this calculation, invert elevation is considered equivalent to bed material surface as shown on drawing)
H	3.5 ft	
HW	8.9 ft	
WSE	213.7	

Note:
Equation for outlet control headloss from outlet control nomographs is from "Handbook of Concrete Culvert Pipe Hydraulics".

Forbes Creek Fishway
100-Year Weir Flow Calculation at Fishway Head Pool

weir constant (C)	3.3	
head pool water surface elev.	209.04	
fishway flow*		**83.00 cfs**
overflow bypass weir length (L)	19 ft	
overflow bypass weir crest elev.	207.29	
overflow bypass weir head (H)	1.75 ft	
overflow bypass flow = CLH^1.5		**145.38 cfs**
TOTAL FLOW		**228.38 cfs**

*Fishway flow greater than 18 cfs results in a submerged weir flow condition that cannot be calculated using the free-discharge weir equation. See submerged weir calculation sheet attached.

Forbes Creek Fishway
100-Year Submerged Fishway Weir Calculation

weir length	8 ft	(required)
weir coef.	3.3	(required)
flow required	83.0 cfs	(required)
Q free discharge	173.0 cfs	(assumed)
H u.s. (free discharge)	3.50 ft	(calculated)
H d.s. (submergence)	2.75 ft	(assumed)
Q submerged*	83.1 cfs	(calculated, must match flow required)
head loss	0.75 ft	(calculated)
fishway weir crest elev.	205.54	
fishway forebay WS elev.	**209.04**	

*Submerged weir equation from Civil Engineering Reference Manual, pg. 5-8.
Note: Weir length +/- to be verified in final design.

Forbes Creek Fishway
25-Year Outlet Control Calculation

78" culvert

Q	165 cfs	
D	6.1 ft	(Adjusted culvert size to account for bed fill, equivalent flow area)
n	0.018	(Composite n for steel and streambed material)
Ke	0.35	(Headwall with square-edged entrance and 45-degree wingwalls)
L	440 ft	
So	0.0016	
ho	4.5 ft	(Approximate fishway forebay depth at 165 cfs)
upstream IE	204.8	(For purposes of this calculation, invert elevation is considered equivalent to bed material surface as shown on drawing)
H	1.9 ft	
HW	5.7 ft	
WSE	210.5	

Note:
Equation for outlet control headloss from outlet control nomographs is from "Handbook of Concrete Culvert Pipe Hydraulics".

Forbes Creek Fishway
25-Year Weir Flow Calculation at Fishway Head Pool

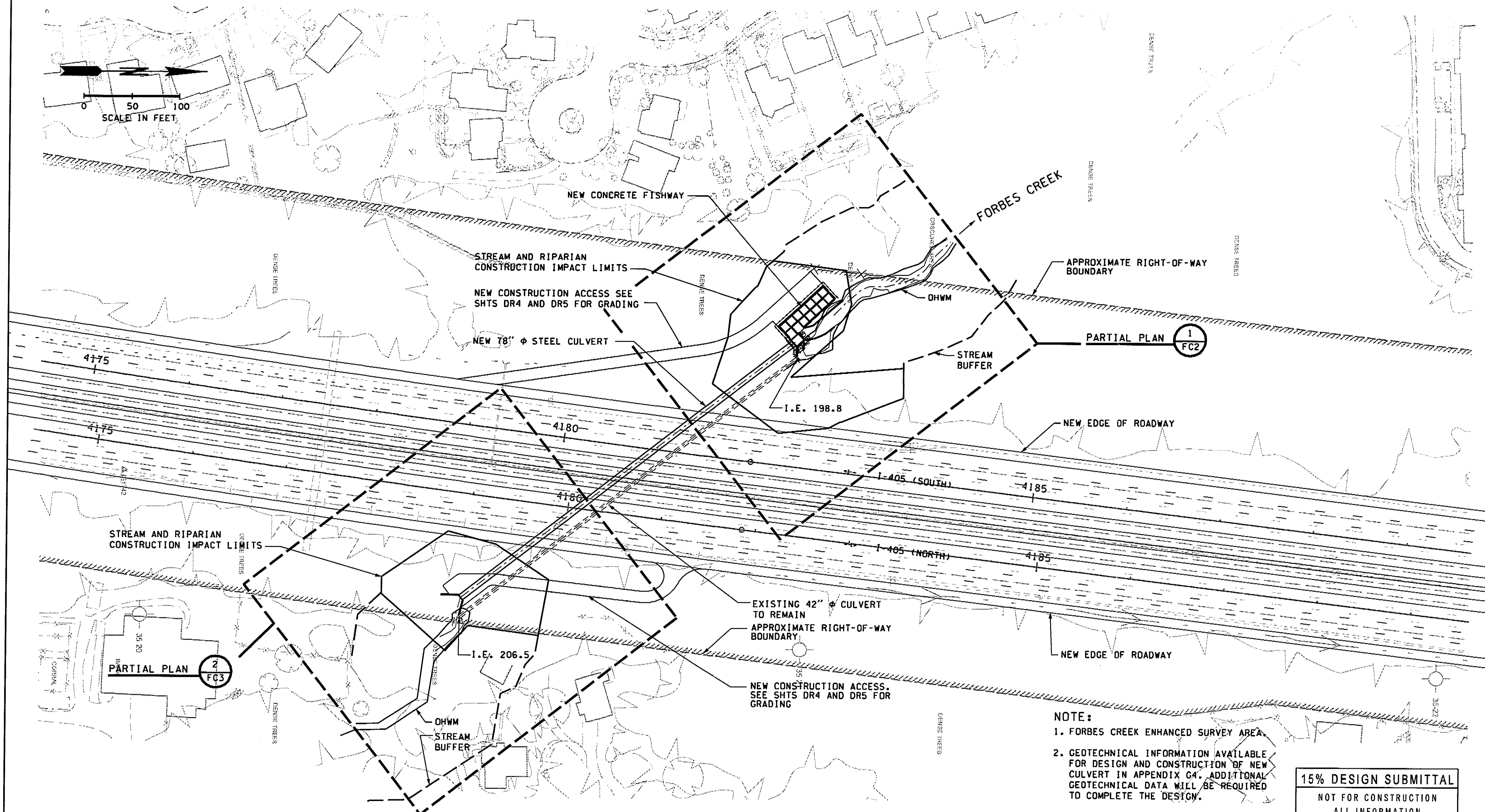
weir constant (C)	3.3	
head pool water surface elev.	208.60	
fishway flow*		**71.00 cfs**
overflow bypass weir length (L)	19 ft	
overflow bypass weir crest elev.	207.29	
overflow bypass weir head (H)	1.31 ft	
overflow bypass flow = CLH^1.5		**93.52 cfs**
TOTAL FLOW		**164.52 cfs**

*Fishway flow greater than 18 cfs results in a submerged weir flow condition that cannot be calculated using the free-discharge weir equation. See submerged weir calculation sheet attached.

Forbes Creek Fishway
25-Year Submerged Fishway Weir Calculation

weir length	8 ft	(required)
weir coef.	3.3	(required)
flow required	71.0 cfs	(required)
Q free discharge	141.0 cfs	(assumed)
H u.s. (free discharge)	3.06 ft	(calculated)
H d.s. (submergence)	2.31 ft	(assumed)
Q submerged*	71.3 cfs	(calculated, must match flow required)
head loss	0.75 ft	(calculated)
fishway weir crest elev.	205.54	
fishway forebay WS elev.	**208.60**	

*Submerged weir equation from Civil Engineering Reference Manual, pg. 5-8.
Note: Weir length +/- to be verified in final design.



NOTE:
1. FORBES CREEK ENHANCED SURVEY AREA.
2. GEOTECHNICAL INFORMATION AVAILABLE FOR DESIGN AND CONSTRUCTION OF NEW CULVERT IN APPENDIX G4. ADDITIONAL GEOTECHNICAL DATA WILL BE REQUIRED TO COMPLETE THE DESIGN.

15% DESIGN SUBMITTAL
NOT FOR CONSTRUCTION
ALL INFORMATION
NOT INCLUDED

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DESIGNED BY J. NELSON
ENTERED BY X. BERMUDEZ
CHECKED BY W. TAYLOR
PROJ. ENGR. K. HENRY
REGIONAL ADM. D. DYE

REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	

JOB NUMBER
CONTRACT NO. LOCATION NO.

P.E. STAMP BOX DATE
P.E. STAMP BOX DATE

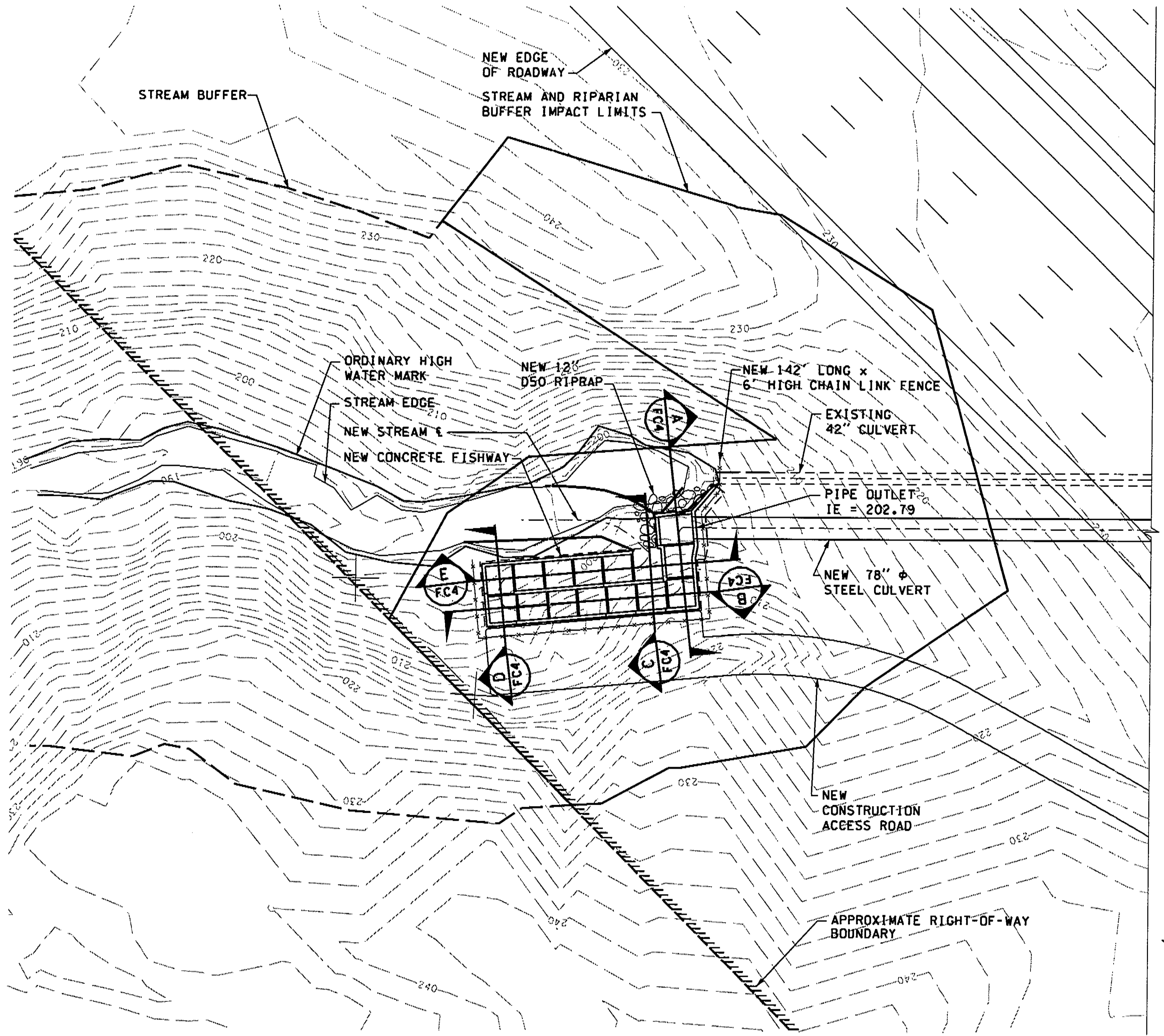
INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405
SR 520 TO SR 522
STAGE 1
FORBES CREEK CULVERT & FISHWAY-SITE PLAN

FC1
SHEET
OF
SHEETS

NOTE:

1. FORBES CREEK ENHANCED SURVEY AREA.
2. GEOTECHNICAL INFORMATION AVAILABLE FOR DESIGN AND CONSTRUCTION OF NEW CULVERT IN APPENDIX G4. ADDITIONAL GEOTECHNICAL DATA WILL BE REQUIRED TO COMPLETE THE DESIGN.



PARTIAL PLAN 1/FC1

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SCALE IN FEET

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NOT FOR CONSTRUCTION
ALL INFORMATION
NOT INCLUDED

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ENTERED BY X. BERMUDEZ
CHECKED BY W. TAYLOR
PROJ. ENGR. K. HENRY
REGIONAL ADM. D. DYE

REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE
P.E. STAMP BOX DATE

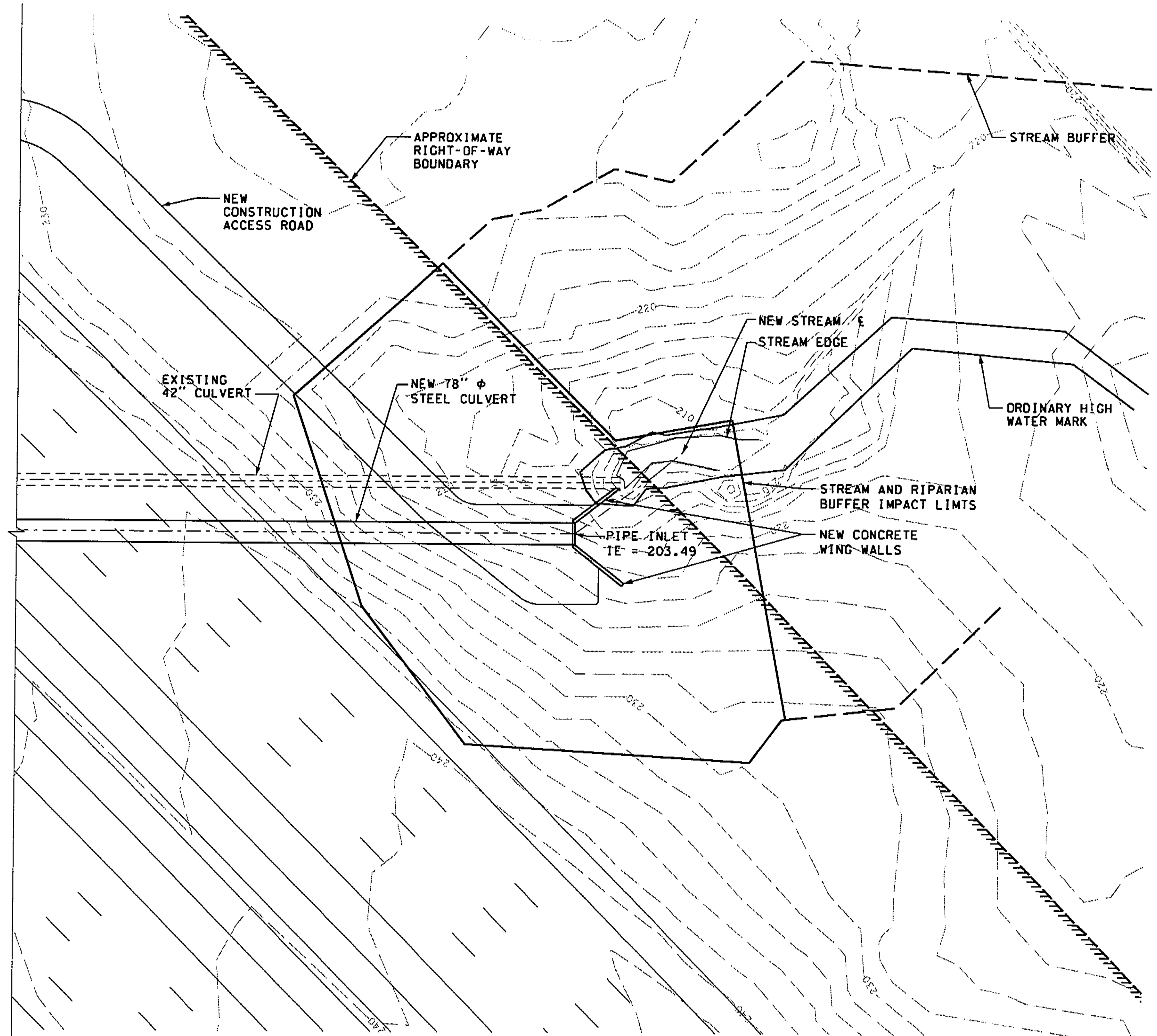
INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405
SR 520 TO SR 522
STAGE 1
FORBES CREEK CULVERT & FISHWAY-PLANS

FC2
SHEET
OF
SHEETS

NOTE:

1. FORBES CREEK ENHANCED SURVEY AREA.
2. GEOTECHNICAL INFORMATION AVAILABLE FOR DESIGN AND CONSTRUCTION OF NEW CULVERT IN APPENDIX G4. ADDITIONAL GEOTECHNICAL DATA WILL BE REQUIRED TO COMPLETE THE DESIGN.



PARTIAL PLAN 2 / FC1

15% DESIGN SUBMITTAL

NOT FOR CONSTRUCTION
ALL INFORMATION
NOT INCLUDED

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DESIGNED BY	J. NELSON			
ENTERED BY	X. BERMUDEZ			
CHECKED BY	W. TAYLOR			
PROJ. ENGR.	K. HENRY			
REGIONAL ADM.	D. DYE	REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405
SR 520 TO SR 522

STAGE 1

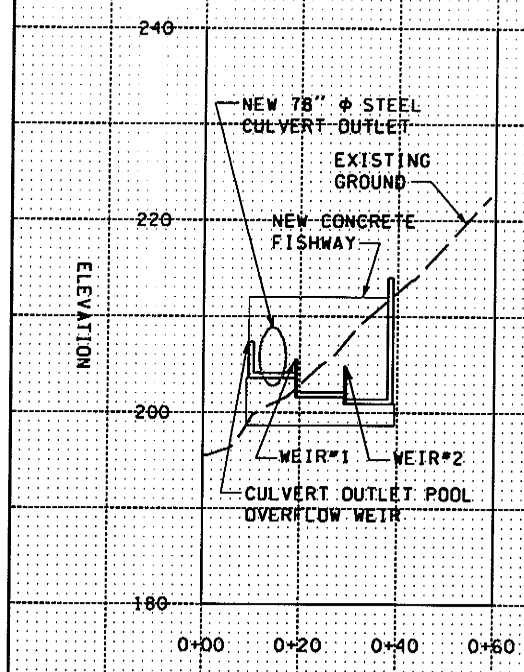
FORBES CREEK CULVERT & FISHWAY-PLANS

FC3

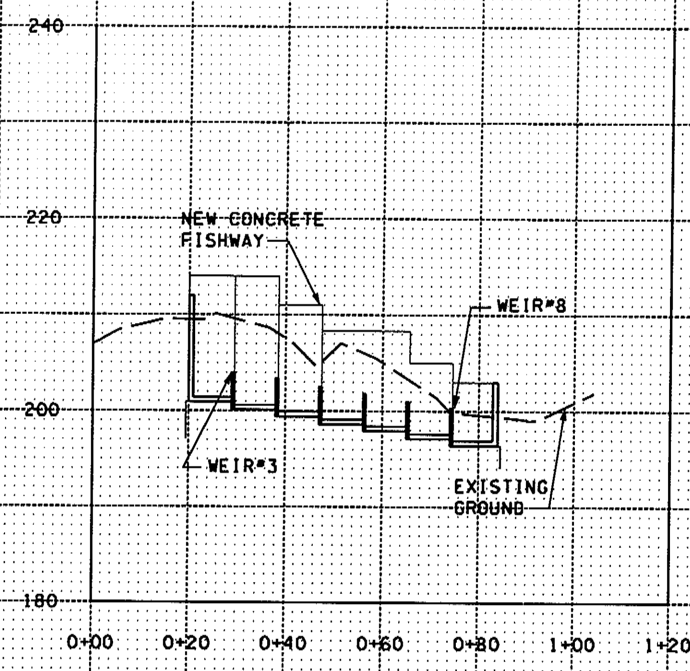
SHEET

OF

SHEETS



SECTION (A / FC2)



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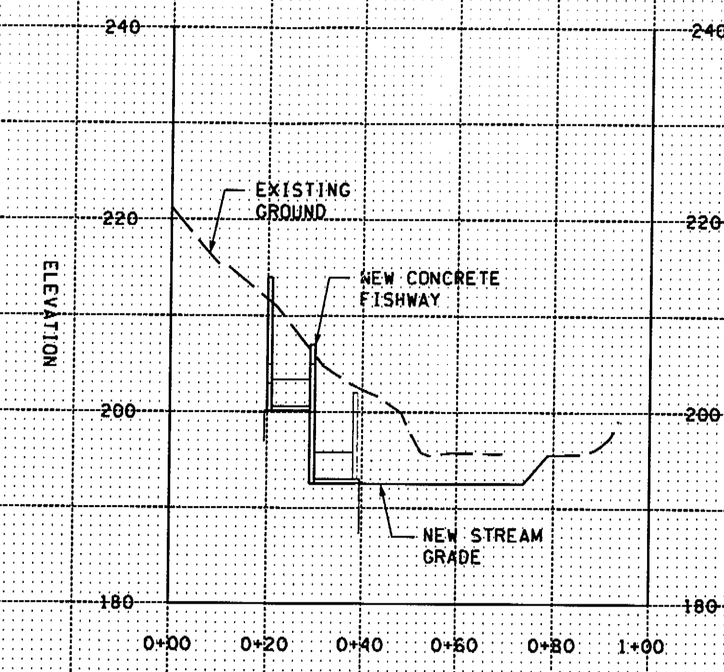

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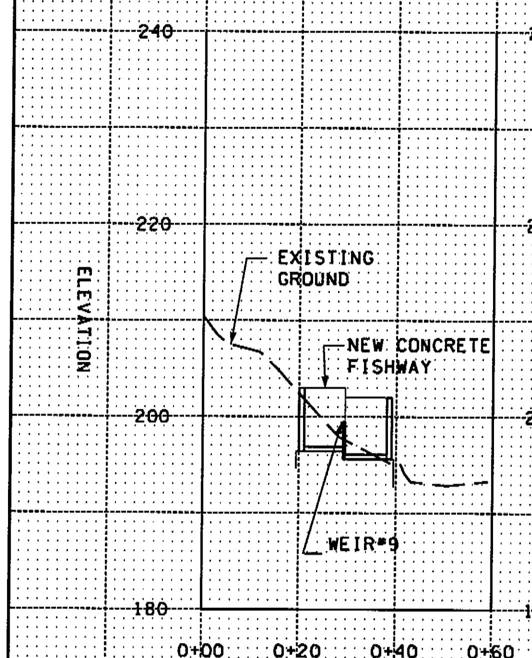

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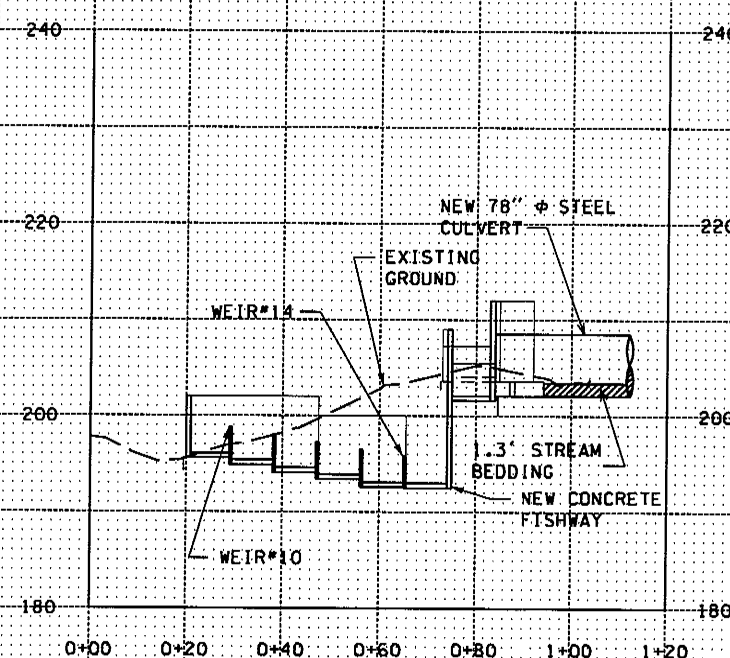
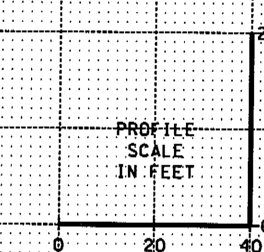


SECTION (E / FC2)

FORBES CREEK FISHWAY STRUCTURE

WEIR *	POOL *	SILL ELEV	POOL FLOOR ELEV
	CULVERT OUTLET		204.09
1		205.54	
	1		202.14
2		204.79	
	2		201.39
3		204.04	
	3		200.64
4		203.29	
	4		199.89
5		202.54	
	5		199.14
6		201.79	
	6		198.39
7		201.04	
	7		197.64
8		200.29	
	8		196.89
9		199.54	
	9		196.14
10		198.79	
	10		195.39
11		198.04	
	11		194.64
12		197.29	
	12		193.89
13		196.54	
	13		193.14
14		195.79	



15% DESIGN SUBMITTAL
NOT FOR CONSTRUCTION
ALL INFORMATION NOT INCLUDED

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TIME 10:31:54 AM
DATE 1/14/2005
PLOTTED BY ADeGuzman
DESIGNED BY J. NELSON
ENTERED BY X. BERMUDEZ
CHECKED BY W. TAYLOR
PROJ. ENGR. K. HENRY
REGIONAL ADM. D. DYE

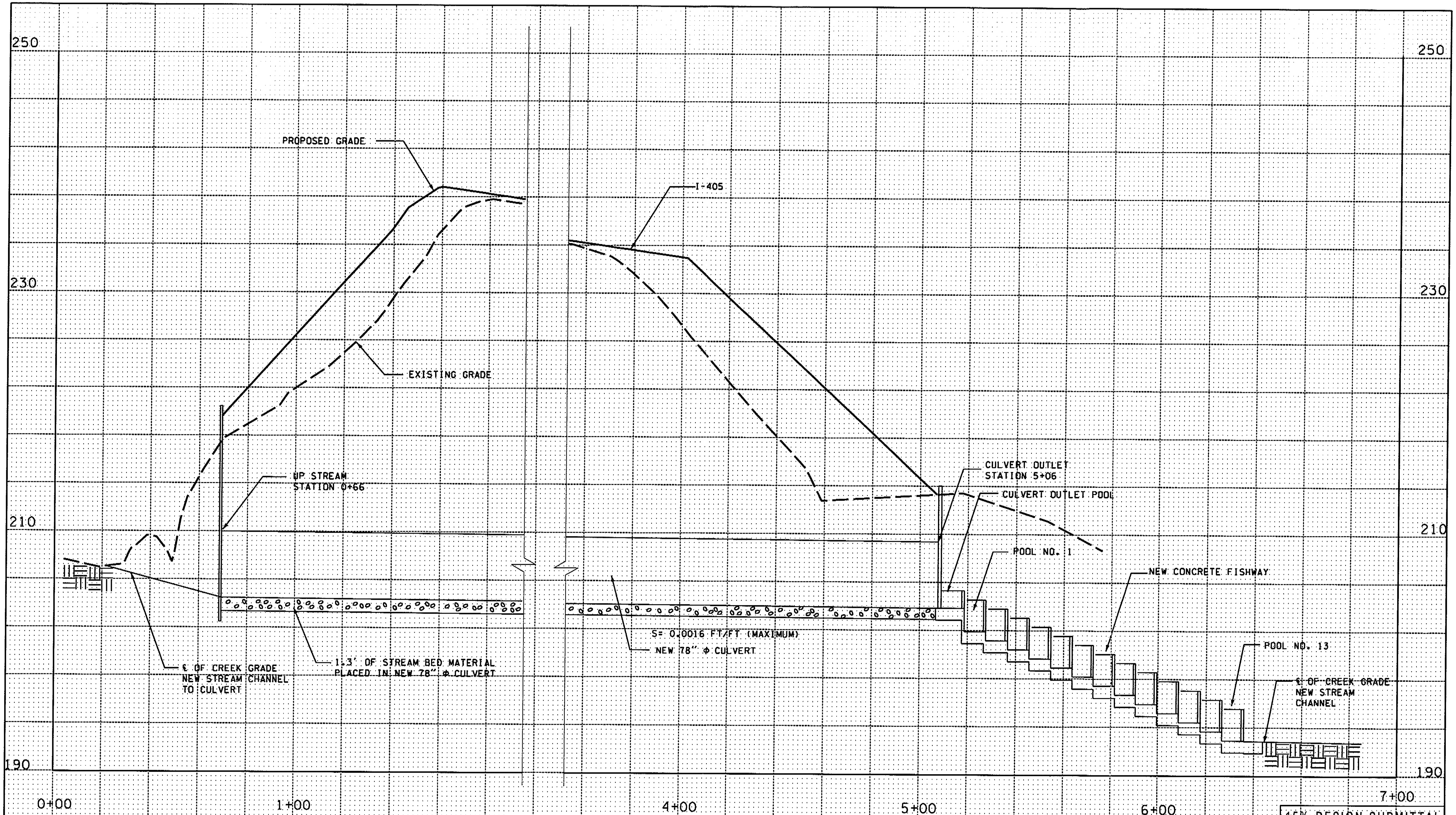
REVISION | DATE | BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.
JOB NUMBER
CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE
P.E. STAMP BOX DATE

I-405
SR 520 TO SR 522
STAGE 1
FORBES CREEK CULVERT & FISHWAY-SECTIONS

FC4
SHEET OF SHEETS



FORBES CREEK CULVERT AND FISHWAY CENTERLINE PROFILE

SCALE: 1" = 20' HORIZONTAL
1" = 4' VERTICAL

15% DESIGN SUBMITTAL
NOT FOR CONSTRUCTION
ALL INFORMATION
NOT INCLUDED

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TIME 10:32:15 AM
DATE 1/14/2005
PLOTTED BY ADeGuzman

DESIGNED BY	J. NELSON			
ENTERED BY	X. BERMUDEZ			
CHECKED BY	W. TAYLOR			
PROJ. ENGR.	K. HENRY			
REGIONAL ADM.	D. DYE	REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

INTERSTATE 405 Project Team
Washington State Department of Transportation

I-405
SR 520 TO SR 522

STAGE 1

FORBES CREEK CULVERT & FISHWAY-PROFILE

FC5

SHEET OF SHEETS

APPENDIX F

DOWNSTREAM ANALYSIS – PROJECT INFLUENCE ON THE RIVERSIDE DRIVE CULVERT AND ASSOCIATED OUTFALL IN BOTHELL

DOWNSTREAM ANALYSIS

PROJECT INFLUENCE ON THE RIVERSIDE DRIVE CULVERT AND ASSOCIATED OUTFALL IN THE SAMMAMISH RIVER BASIN

KING COUNTY - LEVEL 3 COMPLIANT

I-405 CORRIDOR
CONGESTION RELIEF AND BUS RAPID TRANSIT PROJECTS

KIRKLAND NICKEL PROJECT
I-405, SR520 to SR522
Stage 2

January 25, 2005

Preliminary Hydraulics Report – Kirkland Nickel Projects

Downstream Analysis – Project Influence on the Riverside Drive Culvert and Associated Outfall to Sammamish River
Bothell, Washington

This analysis has been prepared to satisfy the City of Bothell request for a King County Level 3 downstream analysis related to the proposed Pond F3 as shown in the Phase 2 Kirkland Nickel Project Preliminary Hydraulic Report.

King County Core Requirement #2: Offsite Analysis notes that the intent of the downstream analysis is "to identify existing or potential/predicable downstream flooding and erosion problems so that the appropriate mitigation, as Specified in Section 1.2.2.2 (p. 1-24), can be provided to prevent aggravation of these problems."

Based on the following calculations, we have confirmed that the existing Riverside Drive culvert is undersized for the existing 100-year recurrent design storm peak flows, and is marginal for the 50-year peak flows. The proposed design is expected to mitigate this deficiency by decreasing peak flows by 20 percent. The duration analysis also shows that the proposed project condition decreases the durations that any given flow rate occurs in the downstream systems.

Existing Condition

Project areas within the Sammamish River basin encompass a portion of I-405 freeway corridor that is benched into the side slope of a ridge as it traverses downhill north toward the Sammamish River and State Route 522 interchange. Paralleling the freeway on the western side is a steep, vegetated and mostly undeveloped ravine running down slope north toward the river and diverging slightly west from the freeway alignment. A small stream runs along the bottom of this ravine. Stream flows descend quickly in the ravine, with portions including a 1000 foot long segment running at 9% slope.

Erosive storm flows from developed areas upstream have contributed to deteriorating conditions in the stream channel, including deep incision of the stream bed, erosion and migration of bed and bank material, and instability of the associated freeway embankments. Of particular concern are two areas of instability along the freeway encroaching on the western edge of the southbound mainline, including areas proposed for pavement widening in the Nickel project. Varying portions of the ravine are listed with King County as "Erosion Hazard", "Landslide Hazard", and "Seismic Hazard" areas.

Contributing stormwater runoff is generated from rainfall within the ravine area, the freeway corridor, and areas lying up-slope east of the freeway corridor. This discrete drainage area has been named TDA-F3 (Threshold Discharge Area F3) by the I-405 project team as a means to identify individual drainage areas along the corridor segment. Figure 1 illustrates the existing drainage configuration for the subject area within the Sammamish River basin and the associated sub-areas.

Flow patterns for this basin convey runoff from the surrounding upland areas to the ravine, then down-slope northwest to the Sammamish River. Beginning in the upper basin, runoff is generated from mostly developed areas (high density residential and commercial). Runoff flows via closed pipe conveyance systems, open ditches, and subterranean interflow down-slope west toward the freeway corridor and the ravine below. Approximately half of the flow generated in the upper basin crosses the freeway through a 42 inch CMP culvert at approximate milepost 22.75, discharging at the west side of the freeway and uppermost end of the drainage ravine.

Other flows originating in the upper basin run down-slope west to the freeway corridor to combine with freeway runoff, entering the roadside ditches flowing down-slope north, and crossing at intervals under the freeway to discharge along the west side freeway embankment. Concentrated flow from these outfalls continues down-slope west to the stream at the base of the ravine. Subterranean flow from the upper basin emerges in seeps along the western freeway embankment to add to the stream.

Near Riverside Drive, the ravine opens to the Sammamish River flood plain where the stream becomes a shallow braided conveyance through wooded and intermittent wetland areas. The stream is characterized by aggrading meanders and frequent channel shifting (from human activity and natural processes) through this stretch as it makes its way to Riverside Drive. At Riverside Drive, the stream enters the roadside ditch where it runs west for approximately 30 feet to enter a catch basin structure and associated 18 inch cross culvert crossing north through the right-of-way.

The catch basin structure at Riverside Drive is fitted with a "beehive" grate to inhibit clogging by stream debris, however stream flow is typically routed to the structure through a short segment of culvert pipe. It is reported that this culvert segment and beehive grate become clogged with debris during high flow conditions, causing flooding in the ditch. Local citizens and City of Bothell officials have reported flooding in the ditch overtopping Riverside Drive and causing damage to the neighboring properties.

From the north side of the right-of-way, the stream outfalls to a plunge pool at the culvert outfall and immediately enters a 24 inch concrete culvert running north under a landscaped berm. This culvert runs north approximately 40 feet and daylights to a man-made concrete channel running along the property line between houses toward the river. Channel flow continues at a moderate slope (approximately 3%) for about 100 feet before transitioning to a contoured concrete slide, descending at rate of approximately 10% slope over an approximate length of 60 feet to the river.

Proposed Condition

Drainage configurations will be adjusted in TDA-F3 to address erosion and stability concerns within the lower drainage ravine, and to improve water quality and flow control characteristics in the basin. Runoff from portions of the upper basin will be collected and routed around the drainage ravine to help reduce erosive storm flows in the ravine. Contributing areas from the upper basin to the ravine will be reduced by approximately 44%. Land area to bypass the ravine consists primarily of undeveloped forest and moderate density residential development. Flows from this "upper basin bypass area" will be conveyed down-slope along the freeway corridor in a closed conveyance system. Within TDA-F3, upper basin bypass flows will be kept separate from freeway flows. At approximate milepost 23.35 a flow splitter will be constructed to distribute runoff to three existing conveyance systems, each with a discreet outfall to the Sammamish River. The design-build contractor will be responsible for design and any necessary system upgrades for conveyance of the proposed bypass flows.

Flow control and water quality treatment will be provided for freeway runoff through construction of a combined stormwater treatment wetland/detention pond facility located in the lower ravine. To convey freeway runoff to the combined facility, a pipe system will be constructed along the west side of the freeway mainline to collect and convey on-site freeway runoff. In the process, existing outfalls along the western freeway embankment will be removed or abandoned. This configuration will change the existing drainage patterns slightly by routing freeway runoff around the ravine area, thus helping to reduce scour in the streambed and decreasing the source of surface water erosion on the associated roadway embankment. Base flow in the stream will be maintained by the continued flows from the majority of the upper basin and associated groundwater flowing under the freeway.

To separate on-site from off-site runoff, new catch basin inlet structures will be installed along the eastern edge of the mainline. Inlets will be situated to connect with the existing storm drain piping and cross culverts under the freeway. New curbing will be constructed along the east edge of the pavement to intercept and channel freeway runoff to the new drain inlets. The cross drain piping will terminate at the new inlet structures so as to prohibit the mingling of off-site runoff from the upper basin bypass area. Figure 2 illustrates the proposed drainage configuration and improvements for the subject area.

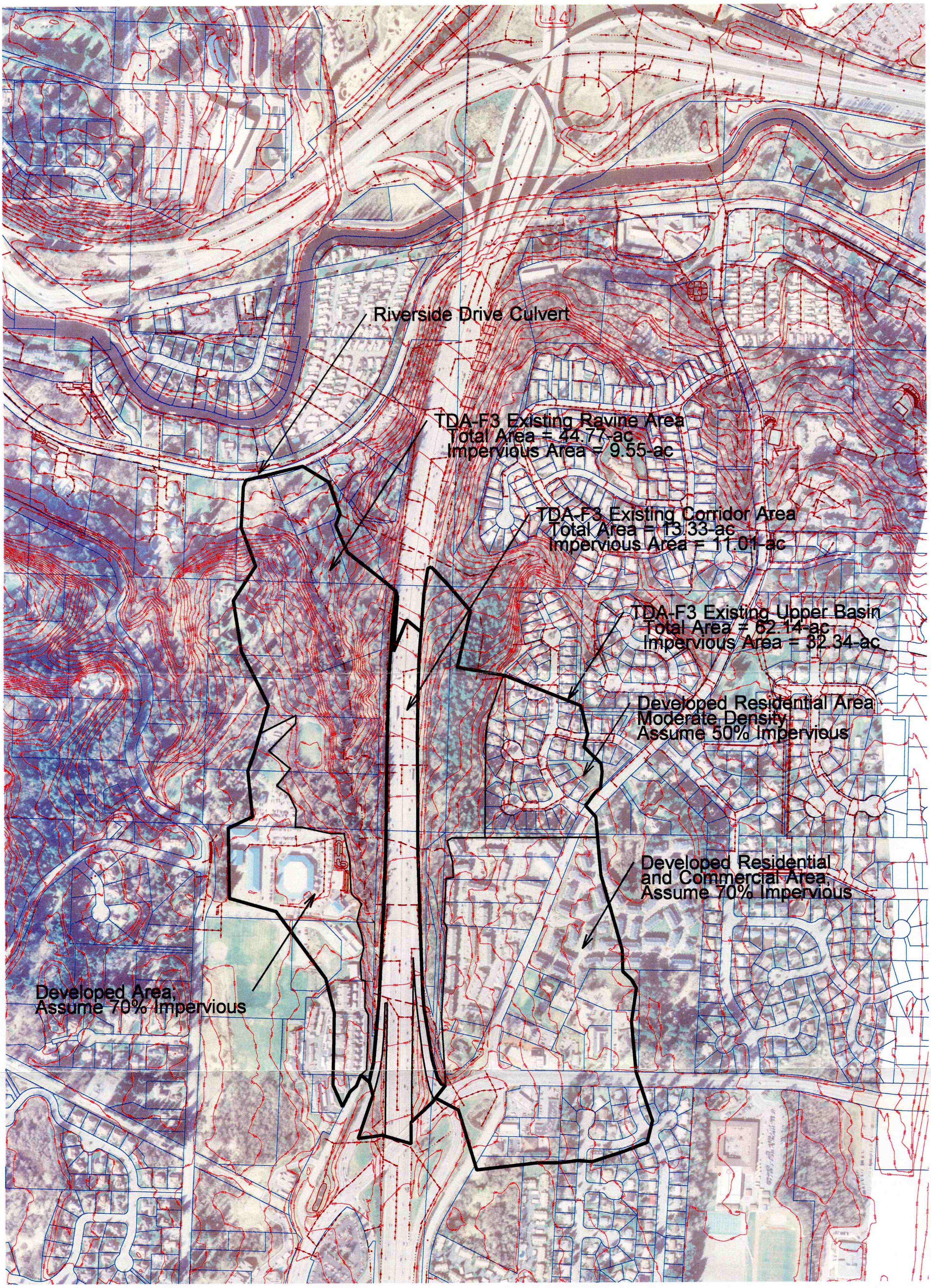


FIGURE 1 EXISTING DRAINAGE CONFIGURATION FOR TDA-F3, SAMMAMISH RIVER BASIN

1" = 500'

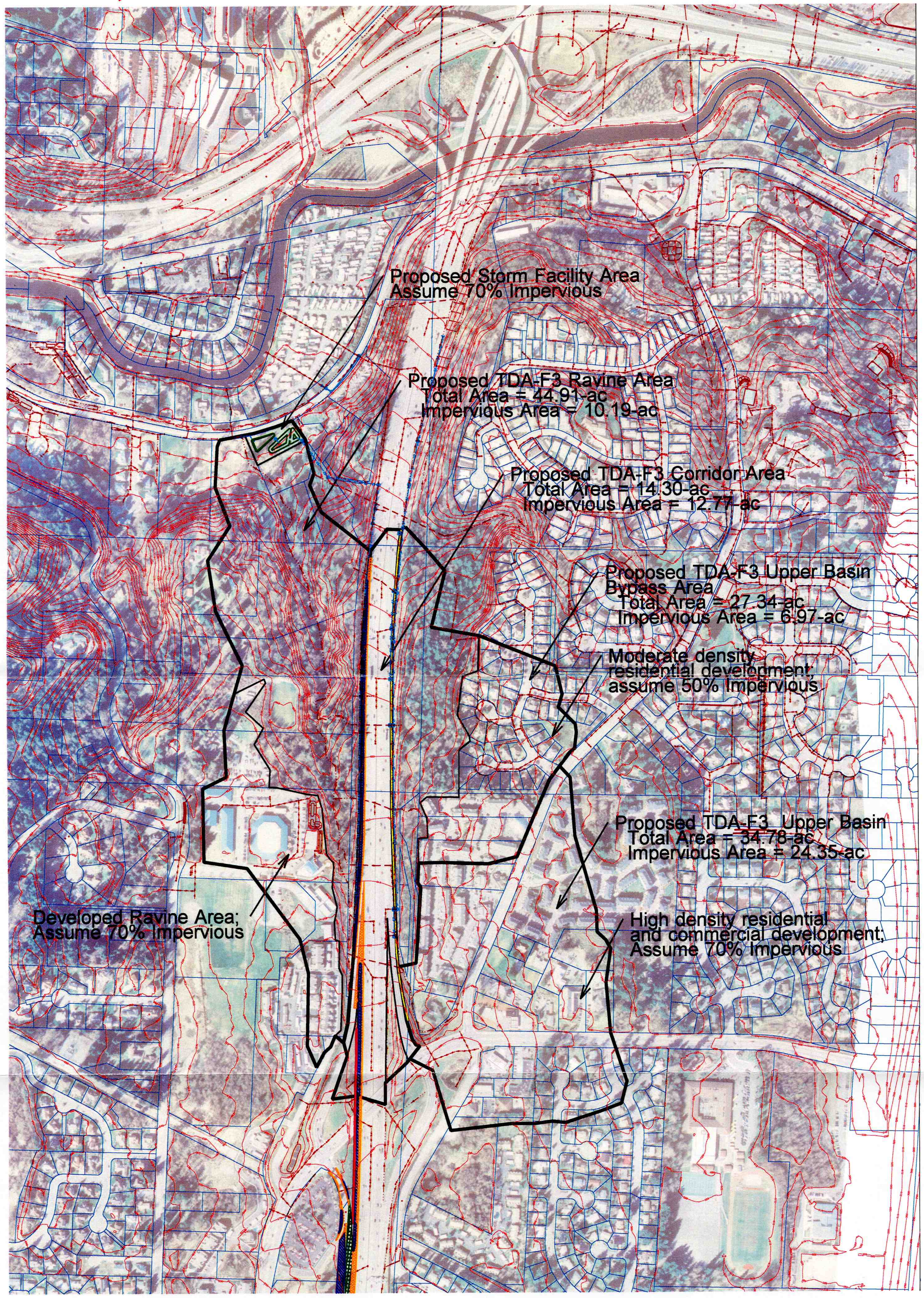


FIGURE 2 PROPOSED DRAINAGE CONFIGURATION FOR TDA-F3, SAMMAMISH RIVER BASIN

1" = 500'

Method of Analysis

The King County Runoff Time Series (KCRTS) continuous hydrologic model was used for the flow analysis. This locally accepted software allows flow analysis based on historical rainfall record. King County notes that rainfall in the City of Bothell is similar to the Seattle rainfall data available in KCRTS. The software also facilitates downstream analysis in drainage systems such as this study where a portion of the basin flows are split off for flow control and then combined back into the system above the point of compliance.

The project data collection has resulted in a very good understanding of the contributing area and flow patterns upstream from the Riverside Drive culvert. Refer to Figures 1 and 2 for an illustration of the existing and proposed basin boundaries, respectively.

Review of the records, project geotechnical documentation, and site observation has resulted in dividing the basin into two distinct soils classifications. The I-405 corridor and upper basin, to the east of I-405, were evaluated as till soils. The ravine reach, to the west of I-405, were evaluated as outwash soils.

KCRTS time series names were defined as follows:

- "F3ex" – Existing total basin flowing to the Riverside Drive culvert
- "F3pd" – Proposed direct discharge basin flowing to the Riverside Drive culvert
- "F3ppin" – Proposed I-405 corridor pond inflow
- "F3ppout"– Proposed I-405 corridor pond outflow
- "F3p" – Combined time series from I-405 corridor pond outflow (F3pout) and the direct discharge basin flowing to the Riverside Drive culvert (F3pd).
- "F3pbp" – Proposed off-site upper basin runoff taken out of the ravine

The "F3ppin" time series file was used to route the Proposed I-405 corridor runoff through proposed pond. The pond was designed using the WSDOT mandated MGS Flood continuous hydrograph software. The stage/storage/discharge output from that model was used to define a single discharge reservoir in KCRTS. The "F3pout" time series was then generated by routing "F3ppin" through this reservoir.

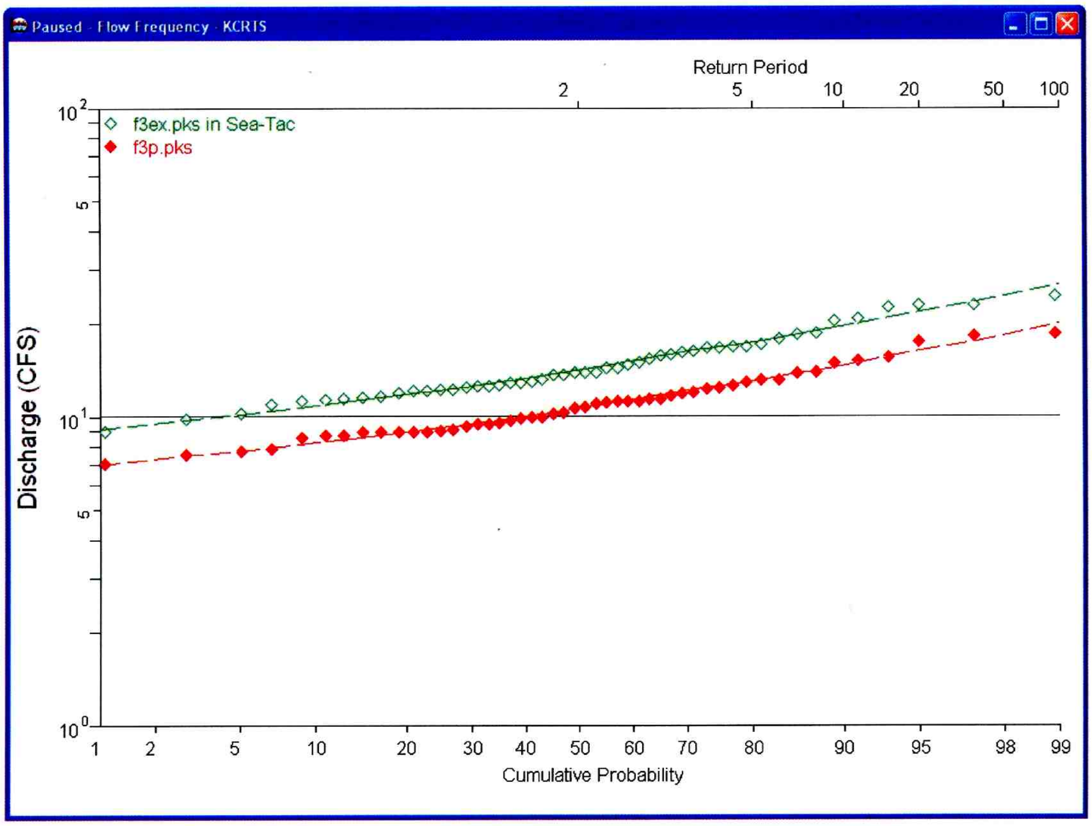
This method is conservative because it does not adjust for the extended hydroperiod and beneficial flow characteristics through the proposed wetland facility or the increased pond sizing generated by the MGS Flood program.

Results

The following figures plot the "F3ex" existing condition time series results against the "F3p" proposed condition time series. Refer to each figure for the legend that applies to each time series.

Figure 3 illustrates the continuous model comparison between existing (pre-project) peak flow rates and those of the proposed condition. The model predicts that the proposed condition will result in peak flows that are 20 percent below the existing condition for the full range of storm events.

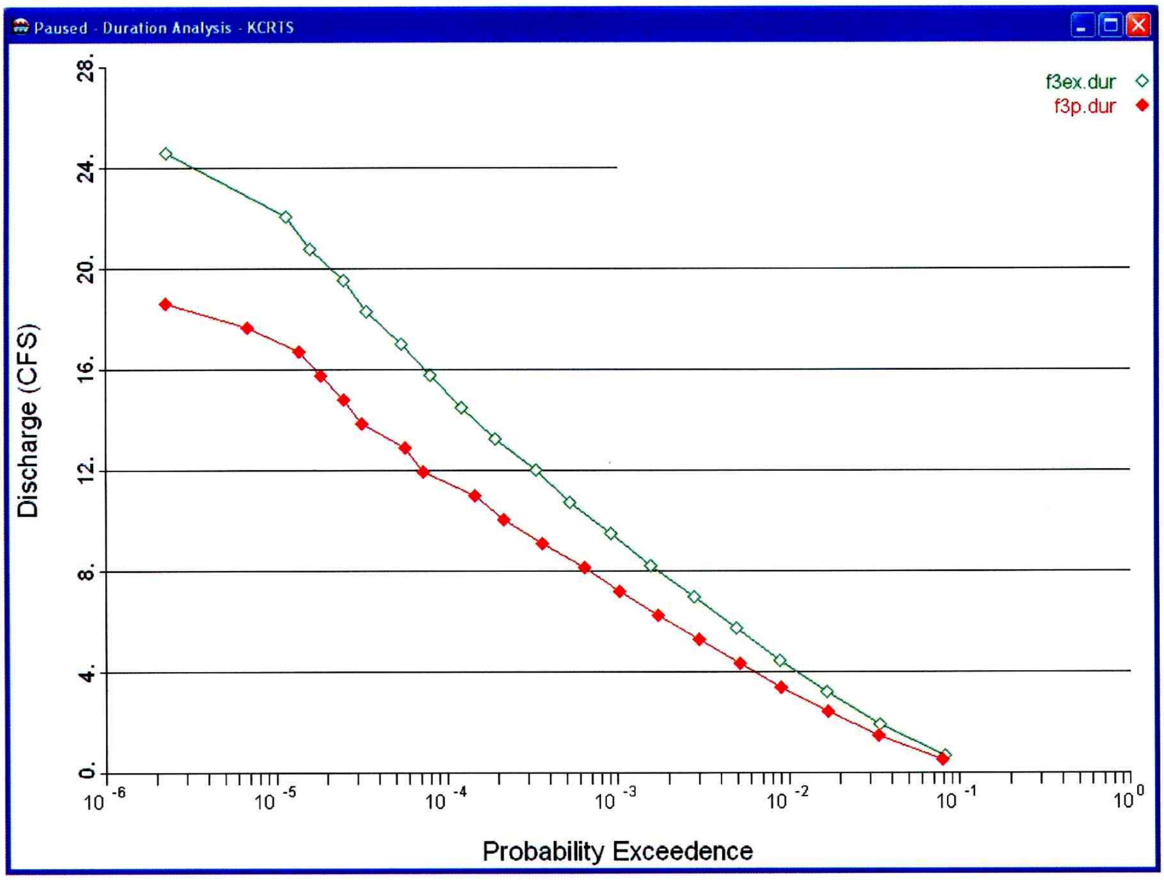
Figure 3 – Peak Flows at the Riverside Drive Culvert



Note: KCRTS adds the "in Sea-Tac" note in the legend to indicate that the Sea-Tac rain gauge data was used as opposed to the other option, "Landsburg". As noted above, Bothell rainfall is the same as Seattle according to King County.

Figure 4 illustrates the continuous model comparison between existing discharge durations reaching the culvert and those of the proposed condition. The model predicts that the proposed condition will result in the probability of any given flow rate reduces by 18 percent relative to the existing condition.

Figure 4 – Probability Exceedence Curves at the Riverside Drive Culvert



Culvert system capacity analyses for the existing system indicate that storm runoff will back-up and overflow Riverside Drive during the 100-year storm event. Additionally, calculated flows for the 50-year storm event are predicted to crest in the ditch at, or very near the roadway elevation. Debris clogging at the inlet may retard the flow performance of the system to the point of overflowing the roadway. Predicted flows for the 25-year storm event are calculated to pass through the culvert system with greater than 1 foot freeboard in the ditch, assuming no blockage in the system.

For the proposed condition, predicted flows from all storm events up to and including the 100-year event are predicted to pass through the culvert system with greater than 1 foot of freeboard (see attached Capacity Analyses).

Conclusions

The analysis confirmed that the proposal to divert flows away from the culvert and provide flow control for the I-405 corridor (as provided by the Kirkland Nickel Project hydraulic designs) will prevent aggravation of existing downstream flooding condition.

The Design-Build Contractor shall verify that the final design also prevents increased peak flow rates and durations at the Riverside Drive culvert and subsequent downstream conveyances.

Input to KCRTS:

Calculate pre-project land cover for input to KCRTS.

TDA-F3 Existing Conditions

Ravine Area			**Measured Land Cover Sq.Ft.from CADD file**	**Calculated Land Cover in Acres**	
Cover Type	**Condition**	**Soil**			
Total		**Outwash**	1,949,979	44.77	Total
Residential (assume 70% impervious)			593,998		
				31.13	Forest
				4.09	Pasture
				9.55	Impervious
I-405 Corridor			**Measured Land Cover Sq.Ft.from CADD file**	**Calculated Land Cover in Acres**	
Cover Type	**Condition**	**Soil**			
Total		**Till**	580,668	13.33	Total
Imprevious			479,734		
				0.00	Forest
				0.00	Pasture
				2.32	Grass
				11.01	Impervious
Upper Basin			**Measured Land Cover Sq.Ft.from CADD file**	**Calculated Land Cover in Acres**	
Cover Type	**Condition**	**Soil**			
Total		**Till**	2,706,639	62.14	Total
Commercial and High Density Residential (70% impervious)			1,795,511		
Moderate Density Residential (50% impervious)			303,588		
				13.95	Forest
				15.85	Pasture
				32.34	Impervious
	KCRTS Input for Existing Condition (Combined basins to culvert) "F3ex"		**Till Forest**	**13.95**	
			Till Pasture	**15.85**	
			Till Grass	**2.32**	
			Outwash Forest	**31.13**	
			Outwash Pasture	**4.09**	
			Outwash Grass	**-**	
			Wetland	**-**	
			Impervious	**52.90**	
			Total	**120.24**	

Flow Frequency Analysis
Time Series File:f3ex.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 1.157 StdDev= 0.101
Skew= 0.476

---Annual Peak Flow Rates---			-----Flow Frequency Analysis-------			
Flow Rate (CFS)	Rank	Time of Peak	- - Peaks - - (CFS)	Rank	Return Period	Prob
14.66	21	2/16/49 21:00	24.54	1	89.50	0.989
22.59	4	3/03/50 16:00	22.92	2	32.13	0.969
14.85	20	2/09/51 2:00	22.81	3	19.58	0.949
12.10	39	10/15/51 13:00	22.59	4	14.08	0.929
11.30	45	3/24/53 15:00	20.66	5	10.99	0.909
13.60	27	12/19/53 19:00	20.30	6	9.01	0.889
14.27	23	11/25/54 2:00	18.60	7	7.64	0.869
13.80	26	11/18/55 15:00	18.43	8	6.63	0.849
16.08	16	12/09/56 14:00	17.78	9	5.86	0.829
14.30	22	12/25/57 16:00	17.02	10	5.24	0.809
10.92	47	11/18/58 13:00	16.81	11	4.75	0.789
13.86	24	11/20/59 5:00	16.73	12	4.34	0.769
12.21	37	2/14/61 21:00	16.67	13	3.99	0.749
12.14	38	11/22/61 2:00	16.59	14	3.70	0.729
12.10	40	12/15/62 2:00	16.28	15	3.44	0.709
13.86	25	12/31/63 23:00	16.08	16	3.22	0.690
12.41	36	12/21/64 4:00	15.83	17	3.03	0.670
12.45	35	1/05/66 16:00	15.63	18	2.85	0.650
18.43	8	11/13/66 19:00	15.28	19	2.70	0.630
20.30	6	8/24/68 16:00	14.85	20	2.56	0.610
11.45	43	12/03/68 16:00	14.66	21	2.44	0.590
12.51	34	1/13/70 22:00	14.30	22	2.32	0.570
11.86	41	12/05/70 9:00	14.27	23	2.22	0.550
17.78	9	2/27/72 7:00	13.86	24	2.13	0.530
11.24	46	1/13/73 2:00	13.86	25	2.04	0.510
12.76	32	11/28/73 9:00	13.80	26	1.96	0.490
17.02	10	12/26/74 23:00	13.60	27	1.89	0.470
11.37	44	12/02/75 20:00	13.58	28	1.82	0.450
13.58	28	8/26/77 2:00	13.13	29	1.75	0.430
18.60	7	9/17/78 2:00	12.94	30	1.70	0.410
16.67	13	9/08/79 15:00	12.86	31	1.64	0.390
15.63	18	12/14/79 21:00	12.76	32	1.59	0.370
16.73	12	11/21/80 11:00	12.64	33	1.54	0.350
22.92	2	10/06/81 0:00	12.51	34	1.49	0.330
16.81	11	10/28/82 16:00	12.45	35	1.45	0.310
13.13	29	1/03/84 1:00	12.41	36	1.41	0.291
11.59	42	6/06/85 22:00	12.21	37	1.37	0.271
15.83	17	1/18/86 16:00	12.14	38	1.33	0.251
20.66	5	10/26/86 0:00	12.10	39	1.30	0.231
9.77	49	11/11/87 0:00	12.10	40	1.27	0.211
12.64	33	8/21/89 17:00	11.86	41	1.24	0.191
24.54	1	1/09/90 6:00	11.59	42	1.21	0.171
22.81	3	11/24/90 8:00	11.45	43	1.18	0.151
12.86	31	1/27/92 15:00	11.37	44	1.15	0.131
8.92	50	11/01/92 16:00	11.30	45	1.12	0.111
10.18	48	11/30/93 22:00	11.24	46	1.10	0.091
12.94	30	11/30/94 4:00	10.92	47	1.08	0.071
16.59	14	2/08/96 10:00	10.18	48	1.05	0.051
15.28	19	1/02/97 6:00	9.77	49	1.03	0.031
16.28	15	10/04/97 15:00	8.92	50	1.01	0.011
Computed Peaks			26.66		100.00	0.990
Computed Peaks			24.46		50.00	0.980
Computed Peaks			22.32		25.00	0.960
Computed Peaks			19.50		10.00	0.900
Computed Peaks			18.93		8.00	0.875
Computed Peaks			17.32		5.00	0.800
Computed Peaks			14.09		2.00	0.500
Computed Peaks			11.98		1.30	0.231

Flow Duration from Time Series File:f3ex.tsf

Cutoff CFS	Count	Frequency %	CDF %	Exceedence_Probability %	
0.645	402354	91.862	91.862	8.138	0.814E-01
1.90	20851	4.761	96.622	3.378	0.338E-01
3.16	7495	1.711	98.333	1.667	0.167E-01
4.42	3450	0.788	99.121	0.879	0.879E-02
5.67	1687	0.385	99.506	0.494	0.494E-02
6.93	934	0.213	99.719	0.281	0.281E-02
8.19	545	0.124	99.844	0.156	0.156E-02
9.44	286	0.065	99.909	0.091	0.909E-03
10.70	167	0.038	99.947	0.053	0.527E-03
11.96	84	0.019	99.966	0.034	0.336E-03
13.21	62	0.014	99.981	0.019	0.194E-03
14.47	31	0.007	99.988	0.012	0.123E-03
15.73	19	0.004	99.992	0.008	0.799E-04
16.98	11	0.003	99.995	0.005	0.548E-04
18.24	9	0.002	99.997	0.003	0.342E-04
19.50	4	0.001	99.997	0.003	0.251E-04
20.75	4	0.001	99.998	0.002	0.160E-04
22.01	2	0.000	99.999	0.001	0.114E-04
23.27	4	0.001	100.000	0.000	0.228E-05
24.53	0	0.000	100.000	0.000	0.228E-05

TDA-F3 **Proposed Conditions**

Ravine Area			**Measured Land Cover Sq.Ft.from CADD file**	**Calculated Land Cover in Acres**	
Cover Type	**Condition**	**Soil**			
Total		**Outwash**	1,956,263	44.91	Total
Residential (assume 70% impervious)			634,050		
				30.25	Forest
				4.37	Pasture
				10.19	Impervious
I-405 Corridor Area discharge to ravine			**Measured Land Cover Sq.Ft.from CADD file**	**Calculated Land Cover in Acres**	
Cover Type	**Condition**	**Soil**			
Total		**Till**	-	-	Total
Imprevious			-		
				0.00	Forest
				0.00	Pasture
				0.00	Grass
				0.00	Impervious
Upper Basin to ravine			**Measured Land Cover Sq.Ft.from CADD file**	**Calculated Land Cover in Acres**	
Cover Type	**Condition**	**Soil**			
Total		**Till**	1,514,926	34.78	Total
Commercial and High Density Residential (70% impervious)			1,514,926		
				0.00	Forest
				10.43	Pasture
				24.35	Impervious

KCRTS Input for Proposed Condition for Direct Discharge (Combined basins to culvert) "F3pd"	**Till Forest**	**-**
	Till Pasture	**10.43**
	Till Grass	**-**
	Outwash Forest	**30.35**
	Outwash Pasture	**4.37**
	Outwash Grass	**-**
	Wetland	**-**
	Impervious	**34.54**
	Total	**79.69**

TDA-F3 Proposed Conditions (Continued)

I-405 Corridor Routed to Proposed Pond					
Cover Type	**Condition**	**Soil**	**Measured Land Cover Sq.Ft.from CADD file**	**Calculated Land Cover in Acres**	
Total		**Till**	622,803	14.30	Total
Imprevious			556,317		
				0.00	Forest
				0.00	Pasture
				1.53	Grass
				12.77	Impervious

Upper Basin Area Routed to Alternate Outfalls					
Cover Type	**Condition**	**Soil**	**Measured Land Cover Sq.Ft.from CADD file**	**Calculated Land Cover in Acres**	
Total		**Till**	1,190,807	27.34	Total
Moderate Density Residential (50% impervious)			607,176		
				13.40	Forest
				6.97	Pasture
				6.97	Impervious

Flow Frequency Analysis
Time Series File:f3pd.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.961 StdDev= 0.099
Skew= 0.509

---Annual Peak Flow Rates---			-----Flow Frequency Analysis-------			
Flow Rate (CFS)	Rank	Time of Peak	- - Peaks - - (CFS)	Rank	Return Period	Prob
9.21	20	2/16/49 21:00	15.20	1	89.50	0.989
13.95	4	3/03/50 16:00	14.79	2	32.13	0.969
9.21	21	2/09/51 2:00	14.19	3	19.58	0.949
7.87	38	10/15/51 13:00	13.95	4	14.08	0.929
7.25	43	3/24/53 15:00	13.41	5	10.99	0.909
8.63	28	12/19/53 19:00	13.13	6	9.01	0.889
9.13	23	11/25/54 2:00	12.08	7	7.64	0.869
8.86	24	11/18/55 15:00	11.92	8	6.63	0.849
10.14	16	12/09/56 14:00	11.06	9	5.86	0.829
9.15	22	12/25/57 16:00	10.90	10	5.24	0.809
6.98	47	11/18/58 13:00	10.85	11	4.75	0.789
8.76	27	11/20/59 5:00	10.79	12	4.34	0.769
7.73	39	2/14/61 21:00	10.63	13	3.99	0.749
7.88	37	11/22/61 2:00	10.53	14	3.70	0.729
7.65	41	12/15/62 2:00	10.18	15	3.44	0.709
8.80	26	12/31/63 23:00	10.14	16	3.22	0.690
7.93	35	12/21/64 4:00	9.92	17	3.03	0.670
7.91	36	1/05/66 16:00	9.77	18	2.85	0.650
11.92	8	11/13/66 19:00	9.57	19	2.70	0.630
13.13	6	8/24/68 16:00	9.21	20	2.56	0.610
7.22	44	12/03/68 16:00	9.21	21	2.44	0.590
7.95	34	1/13/70 22:00	9.15	22	2.32	0.570
7.67	40	12/05/70 9:00	9.13	23	2.22	0.550
11.06	9	12/08/71 18:00	8.86	24	2.13	0.530
7.14	46	1/13/73 2:00	8.83	25	2.04	0.510
8.14	33	11/28/73 9:00	8.80	26	1.96	0.490
10.63	13	12/26/74 23:00	8.76	27	1.89	0.470
7.16	45	12/02/75 20:00	8.63	28	1.82	0.450
8.83	25	8/26/77 2:00	8.36	29	1.75	0.430
12.08	7	9/17/78 2:00	8.34	30	1.70	0.410
10.85	11	9/08/79 15:00	8.26	31	1.64	0.390
9.92	17	12/14/79 21:00	8.20	32	1.59	0.370
10.79	12	11/21/80 11:00	8.14	33	1.54	0.350
14.79	2	10/06/81 0:00	7.95	34	1.49	0.330
10.90	10	10/28/82 16:00	7.93	35	1.45	0.310
8.34	30	1/03/84 1:00	7.91	36	1.41	0.291
7.51	42	6/06/85 22:00	7.88	37	1.37	0.271
9.77	18	1/18/86 16:00	7.87	38	1.33	0.251
13.41	5	10/26/86 0:00	7.73	39	1.30	0.231
6.38	49	11/11/87 0:00	7.67	40	1.27	0.211
8.26	31	8/21/89 17:00	7.65	41	1.24	0.191
15.20	1	1/09/90 6:00	7.51	42	1.21	0.171
14.19	3	11/24/90 8:00	7.25	43	1.18	0.151
8.20	32	1/27/92 15:00	7.22	44	1.15	0.131
5.81	50	11/01/92 16:00	7.16	45	1.12	0.111
6.62	48	11/30/93 22:00	7.14	46	1.10	0.091
8.36	29	11/30/94 4:00	6.98	47	1.08	0.071
10.18	15	2/08/96 10:00	6.62	48	1.05	0.051
9.57	19	1/02/97 6:00	6.38	49	1.03	0.031
10.53	14	10/04/97 15:00	5.81	50	1.01	0.011
Computed Peaks			16.86		100.00	0.990
Computed Peaks			15.47		50.00	0.980
Computed Peaks			14.12		25.00	0.960
Computed Peaks			12.35		10.00	0.900
Computed Peaks			12.00		8.00	0.875
Computed Peaks			10.99		5.00	0.800
Computed Peaks			8.98		2.00	0.500
Computed Peaks			7.67		1.30	0.231

Flow Frequency Analysis
Time Series File:f3ppin.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.527 StdDev= 0.098
Skew= 0.527

---Annual Peak Flow Rates---			-----Flow Frequency Analysis-------			
Flow Rate (CFS)	Rank	Time of Peak	- - Peaks - - (CFS)	Rank	Return Period	Prob
3.38	20	2/16/49 21:00	5.55	1	89.50	0.989
5.07	4	3/03/50 16:00	5.43	2	32.13	0.969
3.32	23	2/09/51 2:00	5.18	3	19.58	0.949
2.91	37	10/15/51 13:00	5.07	4	14.08	0.929
2.68	43	3/24/53 15:00	5.00	5	10.99	0.909
3.18	28	12/19/53 19:00	4.89	6	9.01	0.889
3.35	22	11/25/54 2:00	4.50	7	7.64	0.869
3.27	25	11/18/55 15:00	4.39	8	6.63	0.849
3.72	15	12/09/56 14:00	4.07	9	5.86	0.829
3.38	21	12/25/57 16:00	4.04	10	5.24	0.809
2.55	47	11/18/58 13:00	4.03	11	4.75	0.789
3.19	27	11/20/59 5:00	3.97	12	4.34	0.769
2.85	39	2/14/61 21:00	3.89	13	3.99	0.749
2.92	35	11/22/61 2:00	3.89	14	3.70	0.729
2.82	41	12/15/62 2:00	3.72	15	3.44	0.709
3.23	26	12/31/63 23:00	3.65	16	3.22	0.690
2.93	34	12/21/64 4:00	3.64	17	3.03	0.670
2.90	38	1/05/66 16:00	3.53	18	2.85	0.650
4.39	8	11/13/66 19:00	3.50	19	2.70	0.630
4.89	6	8/24/68 16:00	3.38	20	2.56	0.610
2.63	44	12/03/68 16:00	3.38	21	2.44	0.590
2.92	36	1/13/70 22:00	3.35	22	2.32	0.570
2.83	40	12/05/70 9:00	3.32	23	2.22	0.550
4.07	9	12/08/71 18:00	3.27	24	2.13	0.530
2.61	45	1/13/73 2:00	3.27	25	2.04	0.510
3.02	33	11/28/73 9:00	3.23	26	1.96	0.490
3.89	14	12/26/74 23:00	3.19	27	1.89	0.470
2.61	46	12/02/75 20:00	3.18	28	1.82	0.450
3.27	24	8/26/77 2:00	3.08	29	1.75	0.430
4.50	7	9/17/78 2:00	3.07	30	1.70	0.410
4.03	11	9/08/79 15:00	3.05	31	1.64	0.390
3.65	16	12/14/79 21:00	3.03	32	1.59	0.370
3.97	12	11/21/80 11:00	3.02	33	1.54	0.350
5.43	2	10/06/81 0:00	2.93	34	1.49	0.330
4.04	10	10/28/82 16:00	2.92	35	1.45	0.310
3.07	30	1/03/84 1:00	2.92	36	1.41	0.291
2.79	42	6/06/85 22:00	2.91	37	1.37	0.271
3.53	18	1/18/86 16:00	2.90	38	1.33	0.251
5.00	5	10/26/86 0:00	2.85	39	1.30	0.231
2.36	49	11/11/87 0:00	2.83	40	1.27	0.211
3.05	31	8/21/89 17:00	2.82	41	1.24	0.191
5.55	1	1/09/90 6:00	2.79	42	1.21	0.171
5.18	3	11/24/90 8:00	2.68	43	1.18	0.151
3.03	32	1/27/92 15:00	2.63	44	1.15	0.131
2.16	50	11/01/92 16:00	2.61	45	1.12	0.111
2.46	48	11/30/93 22:00	2.61	46	1.10	0.091
3.08	29	11/30/94 4:00	2.55	47	1.08	0.071
3.64	17	2/08/96 10:00	2.46	48	1.05	0.051
3.50	19	1/02/97 6:00	2.36	49	1.03	0.031
3.89	13	10/04/97 15:00	2.16	50	1.01	0.011
Computed Peaks			6.20		100.00	0.990
Computed Peaks			5.69		50.00	0.980
Computed Peaks			5.19		25.00	0.960
Computed Peaks			4.54		10.00	0.900
Computed Peaks			4.41		8.00	0.875
Computed Peaks			4.04		5.00	0.800
Computed Peaks			3.30		2.00	0.500
Computed Peaks			2.82		1.30	0.231

Stage-Discharge-Storage Definition

based on preliminary MGSFlood design for TDA F3

Single Outflow Table

Stage (Ft)	Discharge (CFS)	Storage (Cu-Ft)	Permeable Area (Sq-Ft)
0.	0.	0.	0.
0.5	0.	1307.	0.
3.06	0.008	10890.	0.
4.01	0.025	15812.	0.
4.48	0.041	18644.	0.
4.52	0.087	18774.	0.
4.56	0.277	19036.	0.
4.64	0.875	19515.	0.
4.98	4.508	21693.	0.
5.06	5.185	22216.	0.
5.14	5.683	22738.	0.

Next Set of stage/discharge relations
Rank Rows–Eliminate Duplicate Stages
Done Editing stage/discharge relations
Enter Discharge at this stage (0.0 at Stage=0.0)

Single Outflow Table

Stage (Ft)	Discharge (CFS)	Storage (Cu-Ft)	Permeable Area (Sq-Ft)
5.3	6.397	23827.	0.
5.54	7.289	25483.	0.
********	********	********	********
********	********	********	********
********	********	********	********
********	********	********	********
********	********	********	********
********	********	********	********
********	********	********	********
********	********	********	********
********	********	********	********

Previous Set of stage/discharge relations
Next Set of stage/discharge relations
Rank Rows–Eliminate Duplicate Stages
Done Editing stage/discharge relations
Enter Discharge at this stage (0.0 at Stage=0.0)

Flow Frequency Analysis
Time Series File:f3ppout.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.471 StdDev= 0.094
Skew= 0.705

---Annual Peak Flow Rates---			-----Flow Frequency Analysis-------				
Flow Rate (CFS)	Rank	Time of Peak	- - Peaks (CFS)	- - (ft)	Rank	Return Period	Prob
3.28	13	2/16/49 21:00	5.36	5.09	1	89.50	0.989
4.13	4	3/03/50 17:00	4.86	5.02	2	32.13	0.969
3.13	20	2/09/51 3:00	4.78	5.01	3	19.58	0.949
2.57	33	10/15/51 13:00	4.13	4.94	4	14.08	0.929
2.53	37	3/24/53 16:00	3.94	4.93	5	10.99	0.909
2.91	25	12/19/53 20:00	3.82	4.92	6	9.01	0.889
3.11	21	11/25/54 2:00	3.72	4.91	7	7.64	0.869
3.23	17	11/18/55 16:00	3.60	4.89	8	6.63	0.849
3.41	12	12/09/56 15:00	3.53	4.89	9	5.86	0.829
2.83	29	1/16/58 12:00	3.52	4.89	10	5.24	0.809
2.32	45	11/18/58 13:00	3.51	4.89	11	4.75	0.789
3.03	22	11/20/59 4:00	3.41	4.88	12	4.34	0.769
2.54	34	11/24/60 8:00	3.28	4.86	13	3.99	0.749
2.38	42	11/22/61 3:00	3.27	4.86	14	3.70	0.729
2.38	43	12/15/62 3:00	3.24	4.86	15	3.44	0.709
3.16	19	12/31/63 23:00	3.23	4.86	16	3.22	0.690
2.49	38	12/21/64 5:00	3.23	4.86	17	3.03	0.670
2.31	46	1/05/66 16:00	3.22	4.86	18	2.85	0.650
3.53	9	11/13/66 20:00	3.16	4.85	19	2.70	0.630
3.60	8	8/24/68 17:00	3.13	4.85	20	2.56	0.610
2.49	39	12/03/68 17:00	3.11	4.85	21	2.44	0.590
2.86	27	1/13/70 23:00	3.03	4.84	22	2.32	0.570
2.67	32	12/05/70 10:00	2.98	4.84	23	2.22	0.550
3.72	7	2/27/72 8:00	2.91	4.83	24	2.13	0.530
2.54	35	1/13/73 2:00	2.91	4.83	25	2.04	0.510
2.39	41	12/07/73 6:00	2.87	4.83	26	1.96	0.490
3.24	15	12/27/74 0:00	2.86	4.83	27	1.89	0.470
2.35	44	12/02/75 20:00	2.83	4.82	28	1.82	0.450
2.54	36	8/26/77 2:00	2.83	4.82	29	1.75	0.430
3.52	10	9/22/78 19:00	2.72	4.81	30	1.70	0.410
2.87	26	9/08/79 16:00	2.70	4.81	31	1.64	0.390
3.51	11	12/14/79 22:00	2.67	4.81	32	1.59	0.370
3.27	14	11/21/80 11:00	2.57	4.80	33	1.54	0.350
4.78	3	10/06/81 0:00	2.54	4.80	34	1.49	0.330
3.82	6	10/28/82 17:00	2.54	4.80	35	1.45	0.310
2.41	40	1/03/84 2:00	2.54	4.80	36	1.41	0.291
2.70	31	6/06/85 23:00	2.53	4.79	37	1.37	0.271
3.22	18	1/18/86 14:00	2.49	4.79	38	1.33	0.251
3.94	5	10/26/86 1:00	2.49	4.79	39	1.30	0.231
2.30	47	11/11/87 1:00	2.41	4.78	40	1.27	0.211
2.29	48	11/05/88 15:00	2.39	4.78	41	1.24	0.191
5.36	1	1/09/90 7:00	2.38	4.78	42	1.21	0.171
4.86	2	11/24/90 9:00	2.38	4.78	43	1.18	0.151
2.98	23	1/27/92 16:00	2.35	4.78	44	1.15	0.131
1.99	50	12/10/92 6:00	2.32	4.78	45	1.12	0.111
2.18	49	11/30/93 23:00	2.31	4.77	46	1.10	0.091
2.72	30	11/30/94 5:00	2.30	4.77	47	1.08	0.071
3.23	16	2/08/96 10:00	2.29	4.77	48	1.05	0.051
2.83	28	11/27/96 15:00	2.18	4.76	49	1.03	0.031
2.91	24	10/04/97 16:00	1.99	4.74	50	1.01	0.011
Computed Peaks			5.45	5.10		100.00	0.990
Computed Peaks			4.98	5.04		50.00	0.980
Computed Peaks			4.52	4.98		25.00	0.960
Computed Peaks			3.94	4.93		10.00	0.900
Computed Peaks			3.83	4.92		8.00	0.875
Computed Peaks			3.51	4.89		5.00	0.800
Computed Peaks			2.88	4.83		2.00	0.500
Computed Peaks			2.50	4.79		1.30	0.231

Flow Frequency Analysis
Time Series File:f3p.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 1.065 StdDev= 0.098
Skew= 0.544

---Annual Peak Flow Rates---			-----Flow Frequency Analysis-------			
Flow Rate (CFS)	Rank	Time of Peak	- - Peaks - - (CFS)	Rank	Return Period	Prob
12.49	17	2/16/49 21:00	19.87	1	89.50	0.989
16.71	4	3/03/50 16:00	19.58	2	32.13	0.969
12.02	21	2/09/51 2:00	18.68	3	19.58	0.949
10.44	32	10/15/51 13:00	16.71	4	14.08	0.929
9.12	46	9/30/53 6:00	16.30	5	10.99	0.909
10.94	27	12/19/53 19:00	16.02	6	9.01	0.889
12.25	18	11/25/54 2:00	14.87	7	7.64	0.869
11.88	23	11/18/55 16:00	14.87	8	6.63	0.849
13.11	14	12/09/56 14:00	14.09	9	5.86	0.829
11.51	25	12/25/57 16:00	14.05	10	5.24	0.809
9.30	45	11/18/58 13:00	13.89	11	4.75	0.789
11.80	24	11/20/59 5:00	13.39	12	4.34	0.769
9.63	39	2/14/61 21:00	13.27	13	3.99	0.749
9.72	37	11/22/61 2:00	13.11	14	3.70	0.729
9.33	44	11/19/62 9:00	12.80	15	3.44	0.709
11.96	22	12/31/63 23:00	12.62	16	3.22	0.690
10.16	35	12/21/64 4:00	12.49	17	3.03	0.670
10.22	33	1/05/66 16:00	12.25	18	2.85	0.650
14.87	7	11/13/66 19:00	12.25	19	2.70	0.630
16.02	6	8/24/68 16:00	12.12	20	2.56	0.610
9.53	42	12/03/68 16:00	12.02	21	2.44	0.590
10.49	31	1/13/70 23:00	11.96	22	2.32	0.570
9.63	40	12/05/70 9:00	11.88	23	2.22	0.550
14.09	9	12/08/71 18:00	11.80	24	2.13	0.530
9.67	38	1/13/73 2:00	11.51	25	2.04	0.510
9.58	41	12/07/73 5:00	11.39	26	1.96	0.490
13.27	13	12/26/74 23:00	10.94	27	1.89	0.470
9.51	43	12/02/75 20:00	10.94	28	1.82	0.450
11.39	26	8/26/77 2:00	10.90	29	1.75	0.430
14.87	8	9/22/78 19:00	10.63	30	1.70	0.410
10.90	29	9/08/79 15:00	10.49	31	1.64	0.390
12.62	16	12/14/79 22:00	10.44	32	1.59	0.370
14.05	10	11/21/80 11:00	10.22	33	1.54	0.350
19.58	2	10/06/81 0:00	10.18	34	1.49	0.330
13.89	11	10/28/82 16:00	10.16	35	1.45	0.310
10.18	34	1/03/84 1:00	9.95	36	1.41	0.291
9.95	36	6/06/85 22:00	9.72	37	1.37	0.271
12.80	15	1/18/86 16:00	9.67	38	1.33	0.251
16.30	5	10/26/86 0:00	9.63	39	1.30	0.231
8.43	47	11/11/87 1:00	9.63	40	1.27	0.211
8.26	49	8/21/89 17:00	9.58	41	1.24	0.191
19.87	1	1/09/90 6:00	9.53	42	1.21	0.171
18.68	3	11/24/90 8:00	9.51	43	1.18	0.151
10.94	28	1/27/92 16:00	9.33	44	1.15	0.131
7.53	50	12/10/92 6:00	9.30	45	1.12	0.111
8.36	48	11/30/93 22:00	9.12	46	1.10	0.091
10.63	30	11/30/94 4:00	8.43	47	1.08	0.071
13.39	12	2/08/96 10:00	8.36	48	1.05	0.051
12.25	19	1/02/97 6:00	8.26	49	1.03	0.031
12.12	20	10/04/97 15:00	7.53	50	1.01	0.011
Computed Peaks			21.43		100.00	0.990
Computed Peaks			19.65		50.00	0.980
Computed Peaks			17.92		25.00	0.960
Computed Peaks			15.66		10.00	0.900
Computed Peaks			15.21		8.00	0.875
Computed Peaks			13.93		5.00	0.800
Computed Peaks			11.39		2.00	0.500
Computed Peaks			9.75		1.30	0.231

Flow Duration from Time Series File:f3p.tsf

Cutoff CFS	Count	Frequency %	CDF %	Exceedence_Probability %	
0.523	403775	92.186	92.186	7.814	0.781E-01
1.54	19606	4.476	96.662	3.338	0.334E-01
2.56	7179	1.639	98.301	1.699	0.170E-01
3.58	3484	0.795	99.097	0.903	0.903E-02
4.59	1688	0.385	99.482	0.518	0.518E-02
5.61	950	0.217	99.699	0.301	0.301E-02
6.63	554	0.126	99.826	0.174	0.174E-02
7.65	319	0.073	99.898	0.102	0.102E-02
8.66	164	0.037	99.936	0.064	0.642E-03
9.68	120	0.027	99.963	0.037	0.368E-03
10.70	66	0.015	99.978	0.022	0.217E-03
11.72	32	0.007	99.986	0.014	0.144E-03
12.73	31	0.007	99.993	0.007	0.731E-04
13.75	7	0.002	99.994	0.006	0.571E-04
14.77	11	0.003	99.997	0.003	0.320E-04
15.79	2	0.000	99.997	0.003	0.274E-04
16.80	4	0.001	99.998	0.002	0.183E-04
17.82	2	0.000	99.999	0.001	0.137E-04
18.84	3	0.001	99.999	0.001	0.685E-05
19.86	2	0.000	100.000	0.000	0.228E-05

Flow Frequency Analysis
Time Series File:f3ex.tsf

	Peaks (CFS)	Return Period	Prob
Computed Peaks	26.66	100.0	0.990
Computed Peaks	24.46	50.0	0.980
Computed Peaks	22.32	25.0	0.960
Computed Peaks	19.50	10.0	0.900
Computed Peaks	18.93	8.0	0.875
Computed Peaks	17.32	5.0	0.800
Computed Peaks	14.09	2.0	0.500
Computed Peaks	11.98	1.3	0.231

Flow Frequency Analysis
Time Series File:f3p.tsf

	Peaks	Return	Prob	Change from Existing	
	(CFS)	Period		(CFS)	Percent
Computed Peaks	21.43	100.0	0.990	-5.23	-20%
Computed Peaks	19.65	50.0	0.980	-4.81	-20%
Computed Peaks	17.92	25.0	0.960	-4.40	-20%
Computed Peaks	15.66	10.0	0.900	-3.84	-20%
Computed Peaks	15.21	8.0	0.875	-3.72	-20%
Computed Peaks	13.93	5.0	0.800	-3.39	-20%
Computed Peaks	11.39	2.0	0.500	-2.70	-19%
Computed Peaks	9.75	1.3	0.231	-2.23	-19%

Duration Comparison Anaylsis

Base File: f3ex.tsf
New File: f3p.tsf
Cutoff Units: Discharge in CFS

	-----Fraction of Time-----			---------Check of Tolerance-------			
Cutoff	Base	New	%Change	Probability	Base	New	%Change
0.000	0.44E+00	0.67E+00	*******	0.44E+00	0.000	0.025	******
1.00	0.61E-01	0.50E-01	-17.9	0.61E-01	1.00	0.767	-23.3
2.00	0.32E-01	0.25E-01	-22.5	0.32E-01	2.00	1.61	-19.4
3.00	0.18E-01	0.13E-01	-29.0	0.18E-01	3.00	2.45	-18.4
4.00	0.11E-01	0.71E-02	-33.7	0.11E-01	4.00	3.31	-17.3
5.00	0.66E-02	0.41E-02	-37.8	0.66E-02	5.00	4.15	-17.1
6.00	0.42E-02	0.25E-02	-41.0	0.42E-02	6.00	4.97	-17.2
7.00	0.27E-02	0.15E-02	-46.5	0.27E-02	7.00	5.82	-16.8
8.00	0.17E-02	0.88E-03	-48.3	0.17E-02	8.00	6.67	-16.7
9.00	0.11E-02	0.52E-03	-51.8	0.11E-02	9.00	7.53	-16.3
10.00	0.72E-03	0.31E-03	-57.1	0.72E-03	10.00	8.39	-16.1
11.00	0.47E-03	0.19E-03	-60.2	0.47E-03	11.00	9.26	-15.8
12.00	0.33E-03	0.13E-03	-62.3	0.33E-03	12.00	9.84	-18.0
13.00	0.22E-03	0.68E-04	-68.4	0.22E-03	13.00	10.70	-17.7
14.00	0.15E-03	0.53E-04	-64.6	0.15E-03	14.00	11.66	-16.7
15.00	0.96E-04	0.27E-04	-71.4	0.96E-04	15.00	12.30	-18.0
16.00	0.73E-04	0.25E-04	-65.6	0.73E-04	16.00	12.78	-20.1
17.00	0.55E-04	0.14E-04	-75.0	0.55E-04	17.00	13.91	-18.2
18.00	0.34E-04	0.11E-04	-66.7	0.34E-04	18.00	14.56	-19.1
19.00	0.27E-04	0.68E-05	-75.0	0.27E-04	19.00	15.84	-16.6
20.00	0.23E-04	0.00E+00	-100.0	0.23E-04	20.00	16.28	-18.6
21.00	0.16E-04	0.00E+00	-100.0	0.16E-04	21.00	16.97	-19.2
22.00	0.11E-04	0.00E+00	-100.0	0.11E-04	22.00	18.13	-17.6
23.00	0.23E-05	0.00E+00	-100.0	0.23E-05	23.00	19.84	-13.7
24.00	0.23E-05	0.00E+00	-100.0	0.23E-05	24.00	19.84	-17.3

Maximum positive excursion = 0.015 cfs (46.8%)
occurring at 0.031 cfs on the Base Data:f3ex.tsf
and at 0.046 cfs on the New Data:f3p.tsf

Maximum negative excursion = 0.063 cfs (-33.4%)
occurring at 0.188 cfs on the Base Data:f3ex.tsf
and at 0.125 cfs on the New Data:f3p.tsf

Flow Frequency Analysis
Time Series File:f3pdp.tsf
Project Location:Sea-Tac

LogPearson III Coefficients
Mean= 0.341 StdDev= 0.118
Skew= 0.503

---Annual Peak Flow Rates---			-----Flow Frequency Analysis-------			
Flow Rate (CFS)	Rank	Time of Peak	- - Peaks - - (CFS)	Rank	Return Period	Prob
2.40	17	2/16/49 21:00	4.33	1	89.50	0.989
4.02	2	3/03/50 16:00	4.02	2	32.13	0.969
2.65	11	2/09/51 2:00	3.95	3	19.58	0.949
1.76	42	1/30/52 8:00	3.58	4	14.08	0.929
1.66	45	3/24/53 15:00	3.15	5	10.99	0.909
2.10	27	12/19/53 19:00	3.07	6	9.01	0.889
2.34	20	2/07/55 17:00	2.87	7	7.64	0.869
2.33	21	12/20/55 17:00	2.87	8	6.63	0.849
2.59	12	12/09/56 14:00	2.76	9	5.86	0.829
2.11	26	12/25/57 16:00	2.75	10	5.24	0.809
1.66	46	11/18/58 13:00	2.65	11	4.75	0.789
2.34	19	11/20/59 21:00	2.59	12	4.34	0.769
1.90	33	2/14/61 21:00	2.58	13	3.99	0.749
1.66	44	11/22/61 2:00	2.57	14	3.70	0.729
1.90	34	12/15/62 2:00	2.46	15	3.44	0.709
2.16	25	12/31/63 23:00	2.42	16	3.22	0.690
1.84	38	12/21/64 4:00	2.40	17	3.03	0.670
1.95	30	1/05/66 16:00	2.36	18	2.85	0.650
2.58	13	11/13/66 19:00	2.34	19	2.70	0.630
2.76	9	8/24/68 16:00	2.34	20	2.56	0.610
1.87	37	12/03/68 16:00	2.33	21	2.44	0.590
1.95	31	1/13/70 22:00	2.28	22	2.32	0.570
1.88	35	12/06/70 8:00	2.28	23	2.22	0.550
3.07	6	2/27/72 7:00	2.20	24	2.13	0.530
1.78	41	1/13/73 2:00	2.16	25	2.04	0.510
1.90	32	11/28/73 9:00	2.11	26	1.96	0.490
2.87	7	12/26/74 23:00	2.10	27	1.89	0.470
1.87	36	12/02/75 20:00	2.02	28	1.82	0.450
1.82	39	8/26/77 2:00	1.96	29	1.75	0.430
2.46	15	9/17/78 2:00	1.95	30	1.70	0.410
2.20	24	9/08/79 15:00	1.95	31	1.64	0.390
2.42	16	12/14/79 21:00	1.90	32	1.59	0.370
2.36	18	11/21/80 11:00	1.90	33	1.54	0.350
3.58	4	10/06/81 15:00	1.90	34	1.49	0.330
2.28	22	10/28/82 16:00	1.88	35	1.45	0.310
2.02	28	1/03/84 1:00	1.87	36	1.41	0.291
1.56	47	6/06/85 22:00	1.87	37	1.37	0.271
2.87	8	1/18/86 16:00	1.84	38	1.33	0.251
2.75	10	10/26/86 0:00	1.82	39	1.30	0.231
1.35	49	1/14/88 12:00	1.82	40	1.27	0.211
1.67	43	8/21/89 17:00	1.78	41	1.24	0.191
4.33	1	1/09/90 6:00	1.76	42	1.21	0.171
3.95	3	11/24/90 8:00	1.67	43	1.18	0.151
1.96	29	1/27/92 16:00	1.66	44	1.15	0.131
1.32	50	3/22/93 22:00	1.66	45	1.12	0.111
1.35	48	11/30/93 22:00	1.66	46	1.10	0.091
1.82	40	11/30/94 4:00	1.56	47	1.08	0.071
3.15	5	2/08/96 10:00	1.35	48	1.05	0.051
2.57	14	1/02/97 6:00	1.35	49	1.03	0.031
2.28	23	10/04/97 15:00	1.32	50	1.01	0.011
Computed Peaks			4.55		100.00	0.990
Computed Peaks			4.11		50.00	0.980
Computed Peaks			3.69		25.00	0.960
Computed Peaks			3.14		10.00	0.900
Computed Peaks			3.03		8.00	0.875
Computed Peaks			2.73		5.00	0.800
Computed Peaks			2.15		2.00	0.500
Computed Peaks			1.78		1.30	0.231

NOTE:
The downstream analysis for this diverted flow shall be performed as the design continues. This preliminary effort identified three possible discharge routes for this flow: two direct discharge culverts and one open ditch to the Sammamish River.

CAPACITY ANALYSES

- EXISTING CONDITION

GRAVITY FLOW: 45-LF 18" PVC @ 3.7%

$$Q = \frac{1.486}{n} A R^{2/3} \sqrt{S}$$

$n = 0.012$ (STEEL PIPE, ASSUME EQUIV. TO PLASTIC PIPE)

$A = \pi r^2 = \pi (0.75')^2 = 1.767\text{-SF}$ (ASSUME FLOWING FULL)

$R = \frac{\pi r^2}{2\pi r} = \frac{r}{2} = \frac{0.75}{2} = 0.375$ (ASSUME FULL FLOW)

$S = 0.037$ FT/FT

$$Q = \frac{1.486}{0.012} (1.767)(0.375)^{2/3} \sqrt{0.037}$$

$Q = \underline{\underline{21.89\text{ - CFS}}} \longleftarrow$ CALCULATED CAPACITY OF RIVERSIDE DRIVE CULVERT @ FULL FLOW

KCRTS CALCULATED FLOWS – EXISTING CONDITION

$Q_{100} = 26.66\text{-CFS}$

$Q_{50} = 24.66\text{-CFS}$

$Q_{25} = 22.32\text{-CFS}$

Project:	KIRKLAND NICKEL	Computed:	W	Date:	1-14-05
Subject:	BOTHELL DOWNSTREAM ANAL	Checked:	APB	Date:	1-18-05
Task:	RIVERSIDE CULVERT	Page:	2	of:	3
Job #:		No:			

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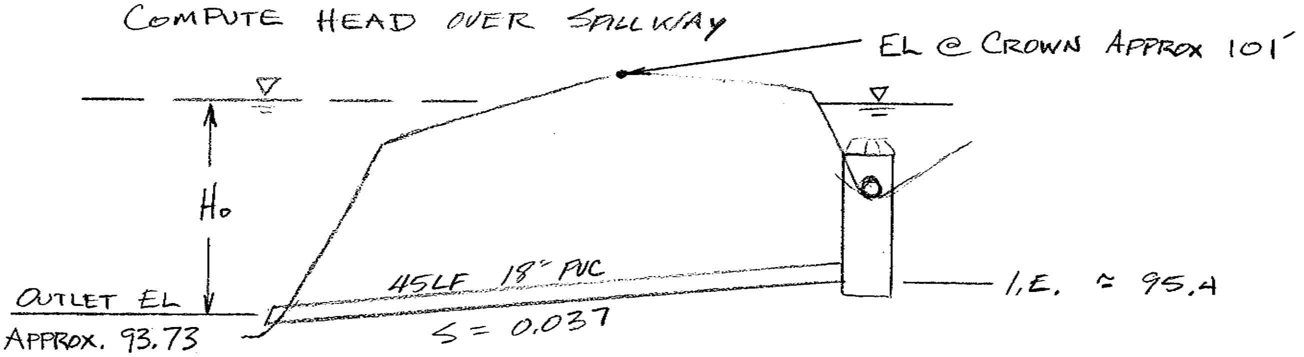
CALCULATE BACKWATER - EXISTING CONDITION

- ASSUMPTION: SYSTEM APPROXIMATES DROP INLET SPILLWAY DURING FULL FLOW CONDITION. SEE ATTACHED "US DEPT. OF AGRICULTURE, ENTRANCE HEAD LOSSES IN DROP INLET SPILLWAYS"

COMPUTE HEAD OVER SPILLWAY



CONDUIT AREA: $A = \pi r^2 = \pi (0.75)^2 = 1.767$ - SF

VELOCITY: $V = Q/A = 21.89/1.767 = 12.4$ - FPS

VELOCITY HEAD: $= V^2/2g = (12.4)^2/2(32.2) = 2.38$ - FT

IF $n = 0.012$: $K_p = 0.0155$ (FROM SCS DWG ES-42)

$$K_p L_p = (0.0155)(45\text{-FT}) = 0.698$$

WITH ROUND CONDUIT & STD COVERED TOP RISER (TABLE 1)

MAXIMUM $K_e = 0.70$ (ASSUMING DEBRIS CLOGGING)

TOTAL HEAD: $H_o = V^2/2g \,(1 + K_e + K_p L_p)$

$$= (2.38)(1 + 0.70 + 0.698)$$

$H_o = \underline{\underline{5.7\text{-FT}}}$ ← SYSTEM HEAD @ FULL FLOW

Project:	KIRKLAND NICKEL	Computed:	JH	Date:	1-14-05
Subject:	BOTHEL D.S.	Checked:	ADB	Date:	1-18-05
Task:	RIVERSIDE CULVERT	Page:	3	of:	3
Job #:		No:			

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CALCULATE HEAD FOR EXISTING STORM EVENTS (FILE f3ex.tsf)

STORM	Q	V	Hv	Ho	ELEVATION
Q100	26.66	15.09	3.53	8.48	102.2' *
Q50	24.46	13.84	2.98	7.14	100.9'
Q25	22.32	12.63	2.48	5.94	99.7'

* : OVERTOP ROADWAY CROWN ELEVATION → APPROX 101'

BACKWATER HEAD FOR Q50 IS MARGINAL

EXISTING FLOWS CALCULATED FOR Q25 STORM EVENT WILL PASS WITH APPROX 1-FT FREEBOARD

CALCULATE HEAD FOR PROPOSED STORM EVENTS (FILE f3p.tsf)

STORM	Q	V	Hv	Ho	ELEVATION
Q100	21.43	12.13	2.28	5.48	99.21
Q50	19.65	11.12	1.92	4.60	98.33
Q25	17.92	10.14	1.59	3.83	97.56

CALCULATED FLOWS FOR PROPOSED CONDITION (FILE: f3p.tsf) WILL PASS WITH > 1-FT FREEBOARD UPWARDS OF Q100 FLOW EVENT

U. S. Dept. of Agriculture
Soil Conservation Service
Engineering Division
Design Branch

August 19, 1969

DESIGN NOTE NO. 8*

Subject: Entrance Head Losses in Drop Inlet Spillways

During the past several years, hydraulic model tests of drop inlet spillways have been in progress at St. Anthony Falls, Minnesota, and Stillwater, Oklahoma. New elbows and transitions have been tested at St. Anthony Falls, and inlets with trash racks and simulated trash have been tested on large-scale models at Stillwater. Although the tests have not been completed and reports are not yet available, considerable information on entrance losses has been obtained which can be used in design.

Table I is a summary of entrance head loss coefficients compiled from a recent review of all available data. The coefficients marked with asterisks were estimated from test data. The others are measured values. All are considered reliable for design purposes.

The nomenclature in this design note is the same as in Technical Release No. 29. The entrance head loss coefficient, K_e, multiplied by the velocity head in the conduit (barrel) gives the total entrance head loss from the reservoir to the conduit, including elbow and transition losses at the conduit entrance. For full pipe flow, as shown in TR 29,

$$H_o = \frac{v_b^2}{2g}(1 + K_e + K_p L_b) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where H_o = total head on the spillway
v_b = mean velocity of flow in the conduit
K_e = entrance head loss coefficient
K_p = friction loss coefficient for the conduit (see ES-42)
L_b = length of the conduit

Figure 1 illustrates how the quantities in Equation (1) are related. The hydraulic grade line usually is considered to intersect the plane of the conduit outlet 0.5D above the invert of the conduit or at the tailwater surface, whichever is higher. H_o is equal to the difference in elevation between the HGL at this point and the reservoir water surface.

*by A. S. Payne, Assistant Chief, Design Branch

TABLE I

ENTRANCE LOSS COEFFICIENTS IN DROP INLET SPILLWAYS

Description of Spillway	Minimum Clear Water K_e	Maximum With Debris K_e
1. Round conduit and Standard Covered Top Riser, except with special elbow and transition (Fig. 2 and ES-150)		
D x 1.5D Riser	0.65	0.75*
D x 2D Riser	0.41	0.50*
D x 3D Riser	0.25	0.35*
D x 5D Riser	0.17	0.30*
2. Round conduit and Standard Covered Top Riser, with round bottom and square-edged entrance to conduit (ES-150) D x 3D Riser	0.60*	0.70*
3. Round conduit and Standard Rectangular Open Top Riser, with round bottom and square-edged entrance to conduit (ES-151) D x 3D Riser	0.50*	0.90*
4. Round conduit and Standard Rectangular Open Top Riser, with flat bottom and square-edged entrance to conduit (ES-151) D x 3D Riser	0.60*	1.10*
5. Round conduit and Standard Square Open Top Riser, with flat bottom and square-edged entrance to conduit (ES-152) (D + 12) x (D + 12) Riser	1.20	2.00*
6. Rectangular conduit[1] with Standard Covered Top Riser, except with flat bottom, and with elbow as shown in Figure 4. Riser width equal to conduit width. $D \geq 4$ ft.,		
B x 3D Riser, Rounded elbow	0.40*	
Special elbow	0.25*	
7. Rectangular conduit[1] with open top riser, no trash rack, and with elbow as shown in Figure 4. Riser width equal to conduit width, $D \geq 5$ ft.,		
B x 3D Riser, Rounded elbow	0.35*	
Special elbow	0.20*	

*Estimated values

[1]Rectangular conduit B wide x D high with B x 3D riser.

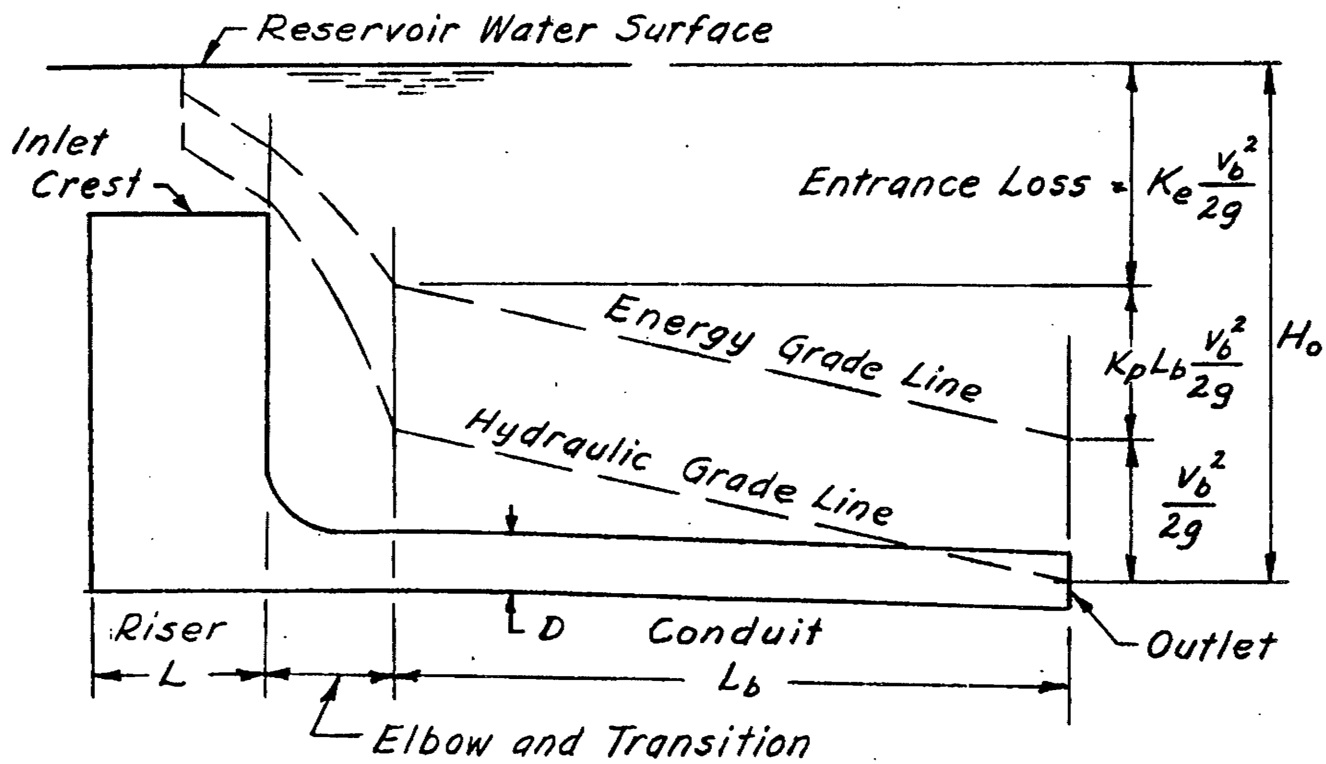


Figure 1. Full Pipe Flow

Special Elbow and Transition

Details of two elbows and a transition tested at St. Anthony Falls, for a rectangular riser and round pipe conduit, are shown in Figure 2 and Figure 3. Hydraulic performance of the two elbows is about the same.

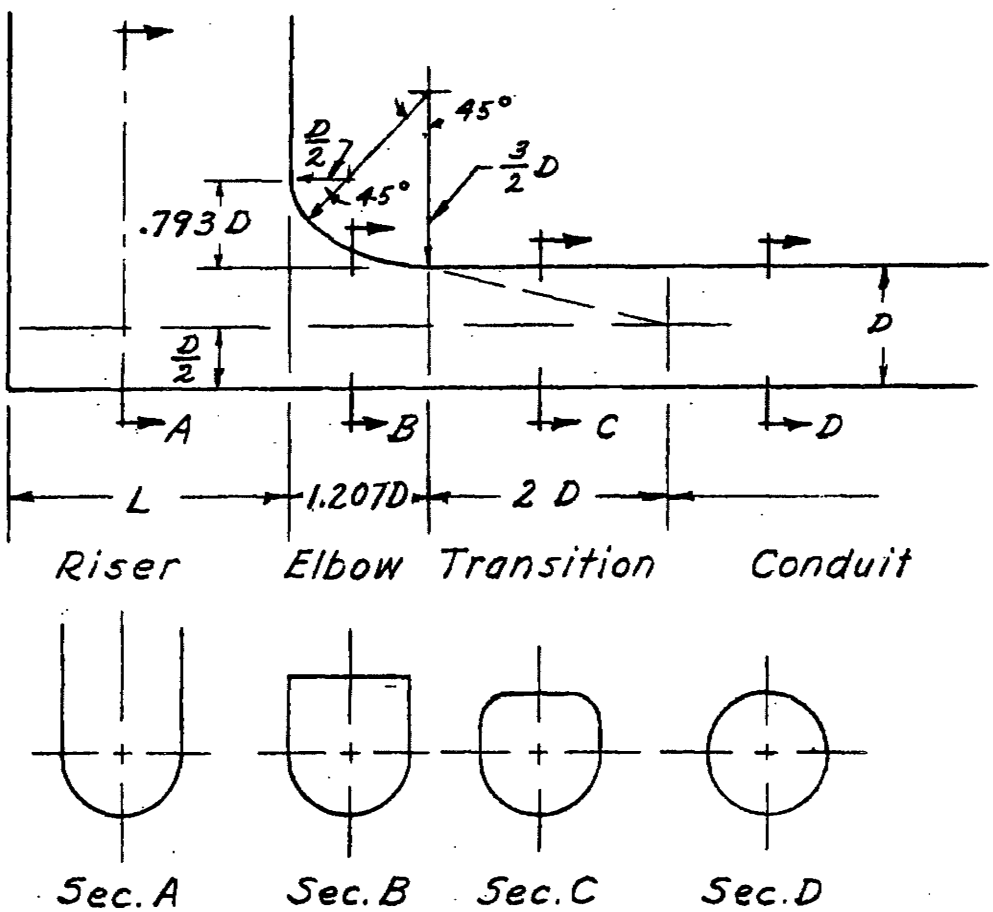


Figure 2. Special Elbow and Transition
(SAF Elbow 6 and Transition A)

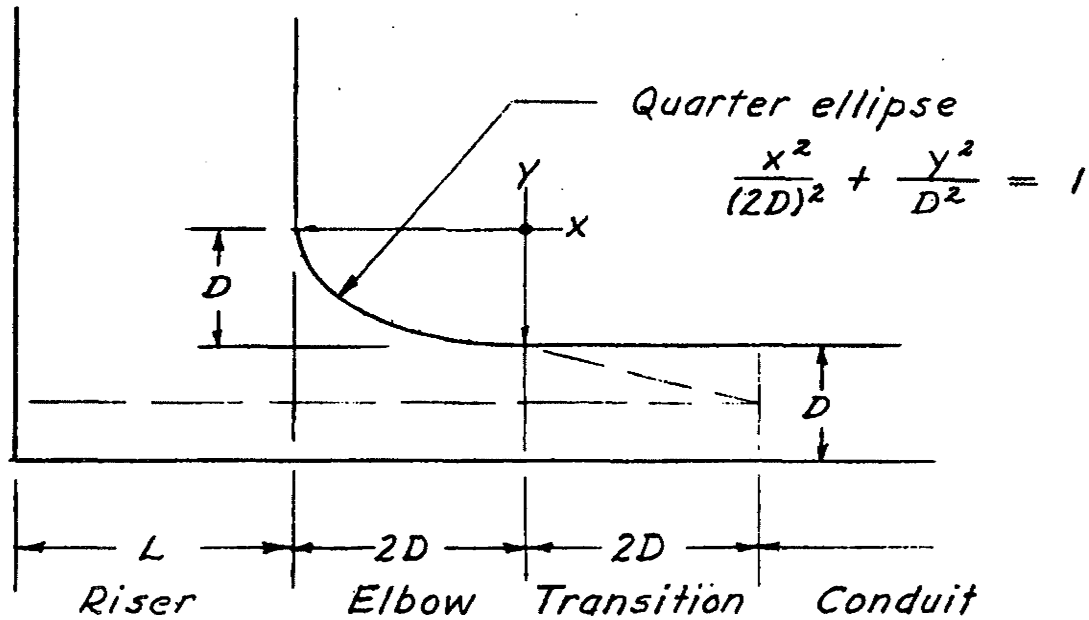


Figure 3. Alternative Special Elbow
(SAF Elbow 3 and Transition A)

The bottom of the riser and the invert of the elbow and transition are horizontal, and form a continuous half-cylinder of diameter D, matching the lower half of the round conduit. The change from horizontal at the outlet of the transition, to the conduit slope farther downstream is made by small angle changes at the first few pipe joints. The elbow is rectangular above the horizontal diameter. The upper half of the transition is rectangular at the upstream end and semicircular at the downstream end. Its surface consists of three plane triangles, on the top and sides, and two quarter-cones. The conical surfaces can be formed from flat sheet stock. Both the elbow and the transition were designed for ease of forming.

The special elbow and transition were developed to fill the need for a smooth transition from a rectangular riser to a round conduit. The standard square-edged conduit entrance is satisfactory in most cases. It is subject to flow separation and a substantial pressure drop just inside the conduit entrance, however, as indicated in TR 29. In large structures, especially high-head, high-velocity structures, the vibrations caused by the resulting turbulence may be intolerable. In some circumstances, the pressure drop may be sufficient to cause cavitation. Little, if any, separation occurs in the special elbow and transition, and the local pressure drop is essentially eliminated. An added advantage is that the energy loss is much less than in the square-edged entrance; enough to make a difference of several feet in the total head required for a given discharge in some cases.

Entrance Loss Coefficients

The "minimum, clear water" values of K_e in Table I represent the condition where minimum losses occur in the trash racks. The "maximum with debris" values are for trash racks partially blocked by debris. The susceptibility of the various types of inlets to clogging with debris was considered in estimating the coefficients.

Minimum coefficients will give the highest discharges and velocities. They should be used in appraising the downstream effects of maximum discharge and in determining the requirements for energy dissipation. Maximum coefficients should be used for establishing reservoir storage volume requirements and computing drawdown time. The relationship between friction loss in the conduit and local pressure deviations will indicate whether maximum or minimum velocities are more critical for cavitation potential.

Table I gives new values of K_e for the Standard Covered Top Riser. In TR 29, a test value of 0.687 is quoted and $K_e = 1.0$ is recommended for design. The tests were made with a flat bottom riser, however, while the standard riser has a round bottom. Losses at the conduit entrance probably are lower with the round bottom riser. Subsequent tests of the special elbow with a round bottom riser have given further support to lower values of K_e. The values in Table I (0.60 and 0.70), therefore, are believed to be the best estimates on the basis of data available thus far.

The coefficients for rectangular conduits are applicable to conduits not less than 4 feet deep having risers with the standard covered top and trash rack (ES-150), and to conduits not less than 5 feet deep having open top risers with no trash racks. Spillways of this size, detailed as indicated, are capable of passing most debris without danger of clogging. Hence, only "clear water" coefficients are applicable. The "rounded" and "special" elbows for which coefficients are given are illustrated in Figure 4.

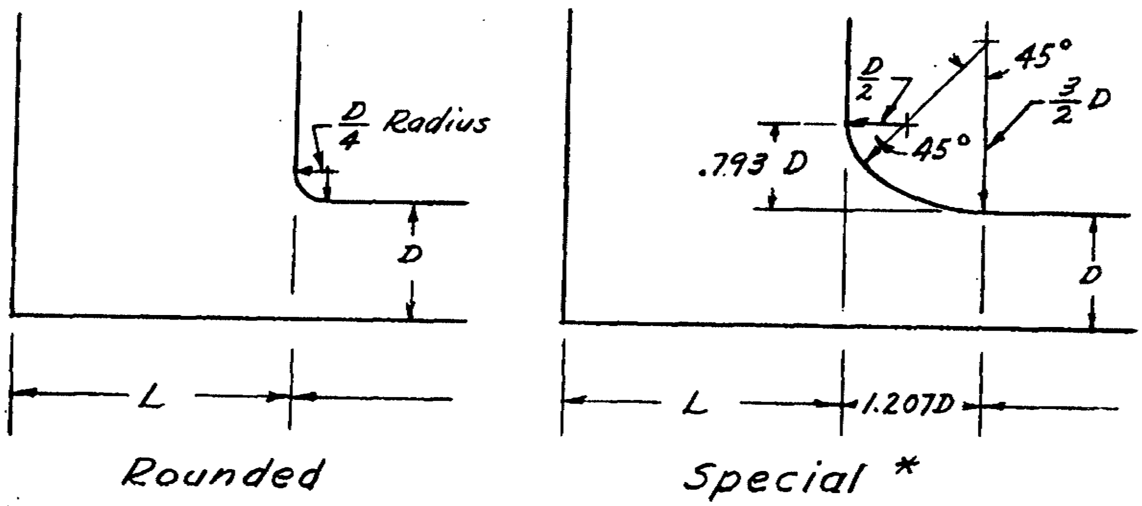


Figure 4. Elbows for Rectangular Conduit
*Elliptical curve may be used for special elbow, as in Fig. 3

Example:

A drop inlet spillway is required to discharge 470 cfs when the reservoir water surface is at the crest of the emergency spillway. Elevation of the hydraulic grade line at the conduit outlet is 100 (assumed datum). The emergency spillway crest elevation is to be approximately 170, and maximum pool level will be 6 feet above the crest. Crest of the principal spillway is to be at elevation 150.

Actual elevation of the structure is about 2000 feet above sea level.

The conduit is to be 380 feet long, on a slope of 6 feet per 100 feet. A 48-inch reinforced concrete pressure pipe conduit with a Standard Covered Top Riser (ES-150) will be tried. Estimated Manning's n for the conduit is .010, minimum, to .013, maximum.

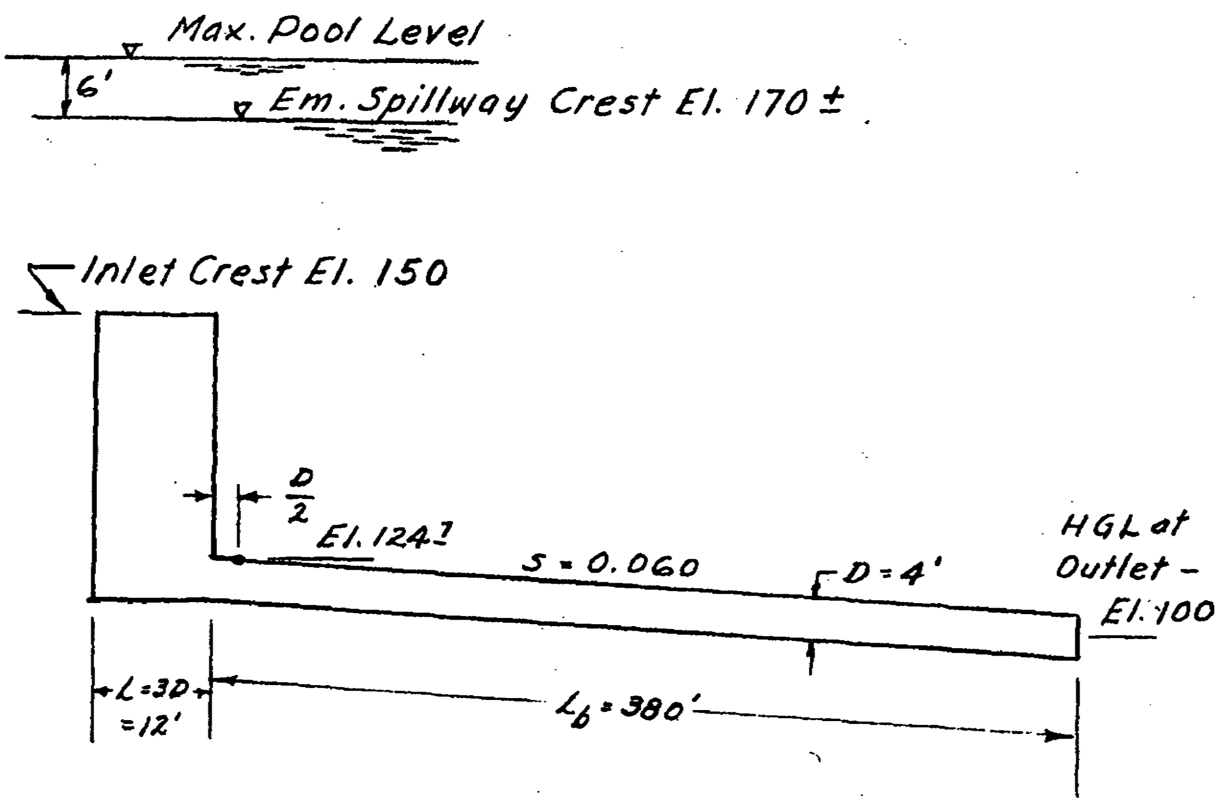


Figure 5. Example

I. Compute required head and emergency spillway crest elevation.

Conduit area $\quad a_b = \pi(2.0)^2 = 12.6 \text{ ft.}^2$

Velocity $\quad v_b = \dfrac{470}{12.6} = 37.3 \text{ fps}$

Velocity head $\quad \dfrac{v_b^2}{2g} = \dfrac{(37.3)^2}{2(32.2)} = 21.6 \text{ ft.}$

If n = .013 $\quad K_p = .00493$ (ES-42)

$K_p L_b = (.00493)(380) = 1.87$

<u>With standard square-edged conduit entrance</u>

Maximum $\quad K_e = 0.70$ (Table I)

Total head $\quad H_o = \dfrac{v_b^2}{2g}(1 + K_e + K_p L_b)$

$= (21.6)(1 + 0.70 + 1.87)$

$= 77.2 \text{ ft.}$

Emergency spillway crest elevation $= 100 + 77.2 = 177$

With special elbow and transition

Maximum $K_e = 0.35$ (Table I)

Total head $H_b = \frac{v_b^2}{2g}(1 + K_e + K_p L_b)$

$= (21.6)(1 + 0.35 + 1.87)$

$= 69.6$ ft.

Emergency spillway crest elevation $= 100 + 69.6 = 170$

II. Compute minimum pressure at conduit entrance

With standard square-edged conduit entrance

Maximum local deviation of hydraulic grade line $= 1.2 \frac{v_b^2}{2g}$ at crown of conduit $\frac{D}{2}$ downstream from entrance (Ref. TR 29).

Elevation of crown of conduit $\frac{D}{2}$ downstream from entrance

$$Z_c = 100 + 0.06 \left(L_b - \frac{D}{2}\right) + \frac{D}{2}$$

$$= 100 + 0.06\ (378) + 2.0 = 124.7$$

Elevation of hydraulic grade line $\frac{D}{2}$ downstream from conduit entrance

$$HGL = 100\ K_p \left(L_b - \frac{D}{2}\right) \frac{v_b^2}{2g} - 1.2 \frac{v_b^2}{2g}$$

If $n = .010$ $K_p = .00292$

$K_p L_b = .00292(380) = 1.11$

$K_p \left(L_b - \frac{D}{2}\right) = .00292(378) = 1.10$

$$HGL = 100 + 1.10 \frac{v_b^2}{2g} - 1.2 \frac{v_b^2}{2g} = 100 - 0.1 \frac{v_b^2}{2g} \quad . \quad . \quad (a)$$

Here, the coefficient applied to velocity head for the local negative deviation of the hydraulic grade line is larger than the positive coefficient for friction head. Therefore, as shown by Equation (a), the low point on the HGL at the conduit entrance will be lowest when the velocity is highest.

∴ To find the lowest pressure, use conditions giving the highest velocity.

Maximum pool elevation = 177 + 6 = 183 ft.

Maximum H_b = 183 - 100 = 83 ft.

Minimum K_e = 0.60 (Table I)

$$H_b = \frac{v_b^2}{2g}(1 + K_e + K_p L_b) = \frac{v_b^2}{2g}(1 + 0.60 + 1.11) = 2.71 \frac{v_b^2}{2g}$$

$$\frac{v_b^2}{2g} = \frac{H_b}{2.71} = \frac{83}{2.71} = 30.6 \text{ ft.}$$

$$HGL = 100 - 0.1 \frac{v_b^2}{2g} = 100 - 0.1 (30.6) = 96.9 \text{ ft.}$$

Pressure head at crown of conduit

$h_{pc} = HGL - Z_c = 96.9 - 124.7 = -27.8$ ft.

Probable minimum atmospheric pressure at elevation 2000 (TR 4, Table II)

= 1876 psf

= 30.0 ft. H_2O

Absolute pressure head at crown of conduit

= 30.0 - 27.8 = 2.2 ft.

This is higher than the vapor pressure of water at usual temperatures, but pulsations could easily produce momentary cavitation pressures locally when the average pressure is this low.

<u>With special elbow and transition</u>

Local deviation of hydraulic grade line is essentially zero.

Elevation of crown of conduit at entrance
(downstream end of transition, Figure 2)

$$Z_c = 100 + 0.06\ (L_b - 3.207D) + \frac{D}{2}$$

$$= 100 + 0.06\ (367.2) + 2.0 = 124.0$$

Elevation of hydraulic grade line at conduit entrance

$$HGL = 100 + K_p\,(L_b - 3.207D)\ \frac{v_b^{\,2}}{2g}$$

If $n = .010 \quad K_p = .00292$

$$K_p L_b = (.00292)(380) = 1.11$$

$$K_p\,(L_b - 3.207D) = (.00292)(367.2) = 1.07$$

$$HGL = 100 + 1.07\ \frac{v_b^{\,2}}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad \text{(b)}$$

In this case, there is no local drop in the hydraulic grade line. The friction head coefficient is positive. Therefore, as shown by Equation (b), the HGL is lowest at the conduit entrance when the velocity is lowest.

∴ To find the lowest pressure, use conditions giving the lowest velocity (with full pipe flow).

Minimum pool elevation for pipe flow

$$= 150 + \frac{D}{2} = 150 + 2.0 = 152 \qquad \text{(TR 29)}$$

Minimum $H_b = 152 - 100 = 52$ ft.

Maximum $K_e = 0.35$ (Table I)

$$H_b = \frac{v_b^{\,2}}{2g}\,(1 + K_e + K_p L_b) = \frac{v_b^{\,2}}{2g}\,(1 + 0.35 + 1.11) = 2.46\ \frac{v_b^{\,2}}{2g}$$

$$\frac{v_b^{\,2}}{2g} = \frac{H_b}{2.46} = \frac{52}{2.46} = 21.1 \text{ ft.}$$

$$HGL = 100 + 1.07 \frac{v_b^2}{2g} = 100 + 1.07 \ (21.1) = 122.6$$

Pressure head at crown of conduit

$$h_{pc} = HGL - Z_c = 122.6 - 124.0 = -1.4 \text{ ft.}$$

Absolute pressure head at crown of conduit (see page 10)

$$= 30.0 - 1.4 = 28.6 \text{ ft.}$$

HYDRAULICS: HEAD LOSS COEFFICIENTS FOR CIRCULAR AND SQUARE CONDUITS FLOWING FULL

HEAD LOSS COEFFICIENT, K_p, FOR CIRCULAR PIPE FLOWING FULL $\quad K_p = \frac{5087\,n^2}{d_i^{4/3}}$

Pipe diam. inches	Flow area sq. ft.	MANNING'S COEFFICIENT OF ROUGHNESS "n"															
		0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.025
6	0.196	0.0467	0.0565	0.0672	0.0789	0.0914	0.1050	0.1194	0.1348	0.151	0.168	0.187	0.206	0.226	0.247	0.269	0.292
8	0.349	.0318	.0385	.0458	.0537	.0623	.0715	.0814	.0919	.1030	.1148	.1272	.140	.154	.168	.183	.199
10	0.545	.0236	.0286	.0340	.0399	.0463	.0531	.0604	.0682	.0765	.0852	.0944	.1041	.1143	.1249	.136	.148
12	0.785	.0185	.0224	.0267	.0313	.0363	.0417	.0474	.0535	.0600	.0668	.0741	.0817	.0896	.0980	.1067	.1157
14	1.069	.0151	.0182	.0217	.0255	.0295	.0339	.0386	.0436	.0488	.0544	.0603	.0665	.0730	.0798	.0868	.0942
15	1.23	.0138	.0166	.0198	.0232	.0270	.0309	.0352	.0397	.0446	.0496	.0550	.0606	.0666	.0727	.0792	.0859
16	1.40	.0126	.0153	.0182	.0213	.0247	.0284	.0323	.0365	.0409	.0455	.0505	.0556	.0611	.0667	.0727	.0789
18	1.77	.01078	.0130	.0155	.0182	.0211	.0243	.0276	.0312	.0349	.0389	.0431	.0476	.0522	.0570	.0621	.0674
21	2.41	.00878	.01062	.0126	.0148	.0172	.0198	.0225	.0254	.0284	.0317	.0351	.0387	.0425	.0464	.0506	.0549
24	3.14	.00735	.00889	.01058	.0124	.0144	.0165	.0188	.0212	.0238	.0265	.0294	.0324	.0356	.0389	.0423	.0459
27	3.98	.00628	.00760	.00904	.01061	.0123	.0141	.0161	.0181	.0203	.0227	.0251	.0277	.0304	.0332	.0362	.0393
30	4.91	.00546	.00660	.00786	.00922	.01070	.01228	.0140	.0158	.0177	.0197	.0218	.0241	.0264	.0289	.0314	.0341
36	7.07	.00428	.00518	.00616	.00723	.00839	.00963	.01096	.0124	.0139	.0154	.0171	.0189	.0207	.0226	.0246	.0267
42	9.62	.00348	.00422	.00502	.00589	.00683	.00784	.00892	.01007	.01129	.0126	.0139	.0154	.0169	.0184	.0201	.0218
48	12.57	.00292	.00353	.00420	.00493	.00572	.00656	.00747	.00843	.00945	.01053	.01166	.0129	.0141	.0154	.0168	.0182
54	15.90	.00249	.00302	.00359	.00421	.00488	.00561	.00638	.00720	.00808	.00900	.00997	.01099	.0121	.0132	.0144	.0156
60	19.63	.00217	.00262	.00312	.00366	.00424	.00487	.00554	.00626	.00702	.00782	.00866	.00955	.01048	.0115	.0125	.0135

HEAD LOSS COEFFICIENT, K_c, FOR SQUARE CONDUIT FLOWING FULL $\quad K_c = \frac{29.16\,n^2}{r^{\frac{4}{3}}}$

Conduit Size feet	Flow area sq. ft.	MANNING'S COEFFICIENT OF ROUGHNESS "n"				
		0.012	0.013	0.014	0.015	0.016
2×2	4.00	0.01058	0.01242	0.01440	0.01653	0.01880
2½×2½	6.25	0.00786	0.00922	0.01070	0.01228	0.01397
3×3	9.00	.00616	.00723	.00839	.00963	.01096
3½×3½	12.25	.00502	.00589	.00683	.00784	.00892
4×4	16.00	.00420	.00493	.00572	.00656	.00746
4½×4½	20.25	.00359	.00421	.00488	.00561	.00638
5×5	25.00	.00312	.00366	.00425	.00487	.00554
5½×5½	30.25	.00275	.00322	.00374	.00429	.00488
6×6	36.00	.00245	.00287	.00333	.00382	.00435
6½×6½	42.25	.00220	.00258	.00299	.00343	.00391
7×7	49.00	.00199	.00234	.00271	.00311	.00354
7½×7½	56.25	.00182	.00213	.00247	.00284	.00323
8×8	64.00	.00167	.00196	.00227	.00260	.00296
8½×8½	72.25	.00154	.00180	.00209	.00240	.00273
9×9	81.00	.00142	.00167	.00194	.00223	.00253
9½×9½	90.25	.00133	.00156	.00180	.00207	.00236
10×10	100.00	.00124	.00145	.00168	.00193	.00220

$$H_1 = (K_p \text{ or } K_c)\, L\, \frac{v^2}{2g}$$

Nomenclature:

a = Cross-sectional area of flow in sq. ft.
d_i = Inside diameter of pipe in inches.
g = Acceleration of gravity = 32.2 ft. per sec.
H_1 = Loss of head in feet due to friction in length L.
K_c = Head loss coefficient for square conduit flowing full.
K_p = Head loss coefficient for circular pipe flowing full.
L = Length of conduit in feet.
n = Manning's coefficient of roughness.
Q = Discharge or capacity in cu. ft. per sec.
r = Hydraulic radius in feet.
v = Mean velocity in ft. per sec.

Example 1: Compute the head loss in 300 ft. of 24 in. diam. concrete pipe flowing full and discharging 30 c.f.s. Assume $n = 0.015$

$$v = \frac{Q}{a} = \frac{30}{3.14} = 9.55 \text{ f.p.s.}; \quad \frac{v^2}{2g} = \frac{(9.55)^2}{64.4} = 1.42 \text{ ft.}$$

$$H_1 = K_p L \frac{v^2}{2g} = 0.0165 \times 300 \times 1.42 = 7.03 \text{ ft.}$$

Example 2: Compute the discharge of a 250 ft., 3×3 square conduit flowing full if the loss of head is determined to be 2.25 ft. Assume $n = 0.014$.

$$H_1 = K_c L \frac{v^2}{2g}; \quad \frac{v^2}{2g} = \frac{H_1}{K_c L} = \frac{2.25}{0.00839 \times 250} = 1.073 \text{ ft.}$$

$$v = \sqrt{64.4 \times 1.073} = 8.31; \quad Q = 9 \times 8.31 = 74.8 \text{ cfs.}$$

REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING STANDARDS UNIT	STANDARD DWG. NO. ES - 42 SHEET 1 OF 1 DATE 7-17-50

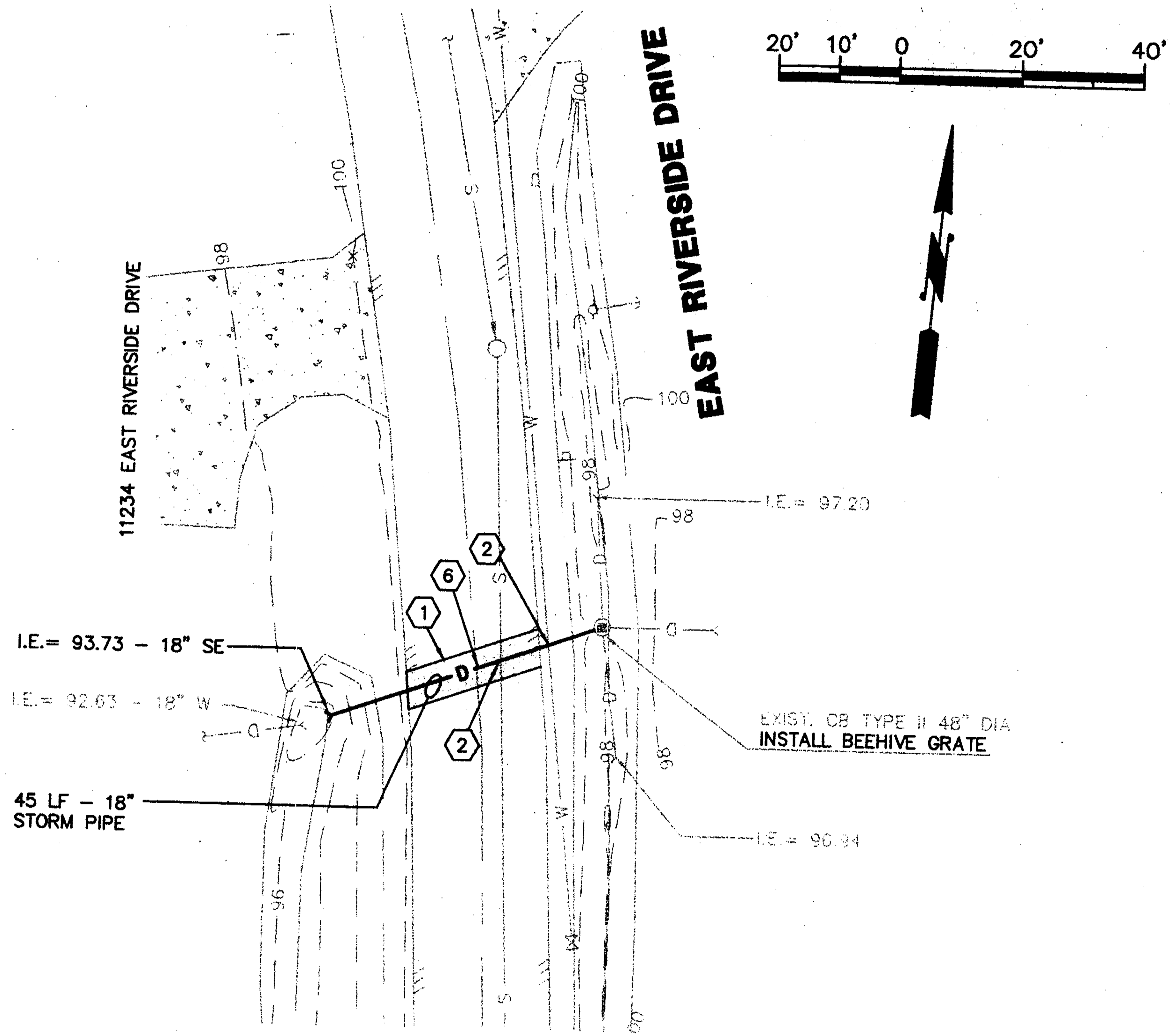
Revised 4-11-51

CONSTRUCTION NOTES

1. CONTRACTOR SHALL SAWCUT EXISTING ASPHALT PAVEMENT, SEAL JOINT WITH AR4000W, THEN APPLY SAND BLANKET TO SURFACE JOINT.
2. CAUTION: POTENTIAL UTILITY CONFLICT. CONTRACTOR SHALL POTHOLE EXISTING UTILITIES AHEAD OF PIPE INSTALLATION TO VERIFY EXACT LOCATION & DEPTH OF EXISTING UTILITY.
3. CONTRACTOR SHALL CONNECT NEW STORM PIPE TO EXISTING CATCH BASIN. (CORE DRILL IF KNOCK-OUT IS NOT PRESENT.)
4. CONTRACTOR SHALL SAWCUT EXISTING CURB & GUTTER PER THE SPECIFICATIONS. WASTEHAUL ALL EXCAVATED MATERIALS AND INSTALL CEMENT CONCRETE CURB & GUTTER IN KIND AS REQUIRED.
5. CONTRACTOR SHALL TAKE CARE NOT TO DAMAGE CONCRETE CURB & GUTTER AND SIDEWALK ALONG 103RD AVENUE NE. SHOULD DAMAGE OCCUR, CONTRACTOR SHALL REPLACE DAMAGED SECTION PER THE CITY OF BOTHELL STANDARD AT NO COST TO THE OWNER.
6. CONTRACTOR SHALL REMOVE AND WASTEHAUL EXISTING STORM DRAINAGE STRUCTURE(S). THIS WORK TO BE INCLUDED IN REMOVAL OF STRUCTURES AND OBSTRUCTIONS.

GENERAL NOTES

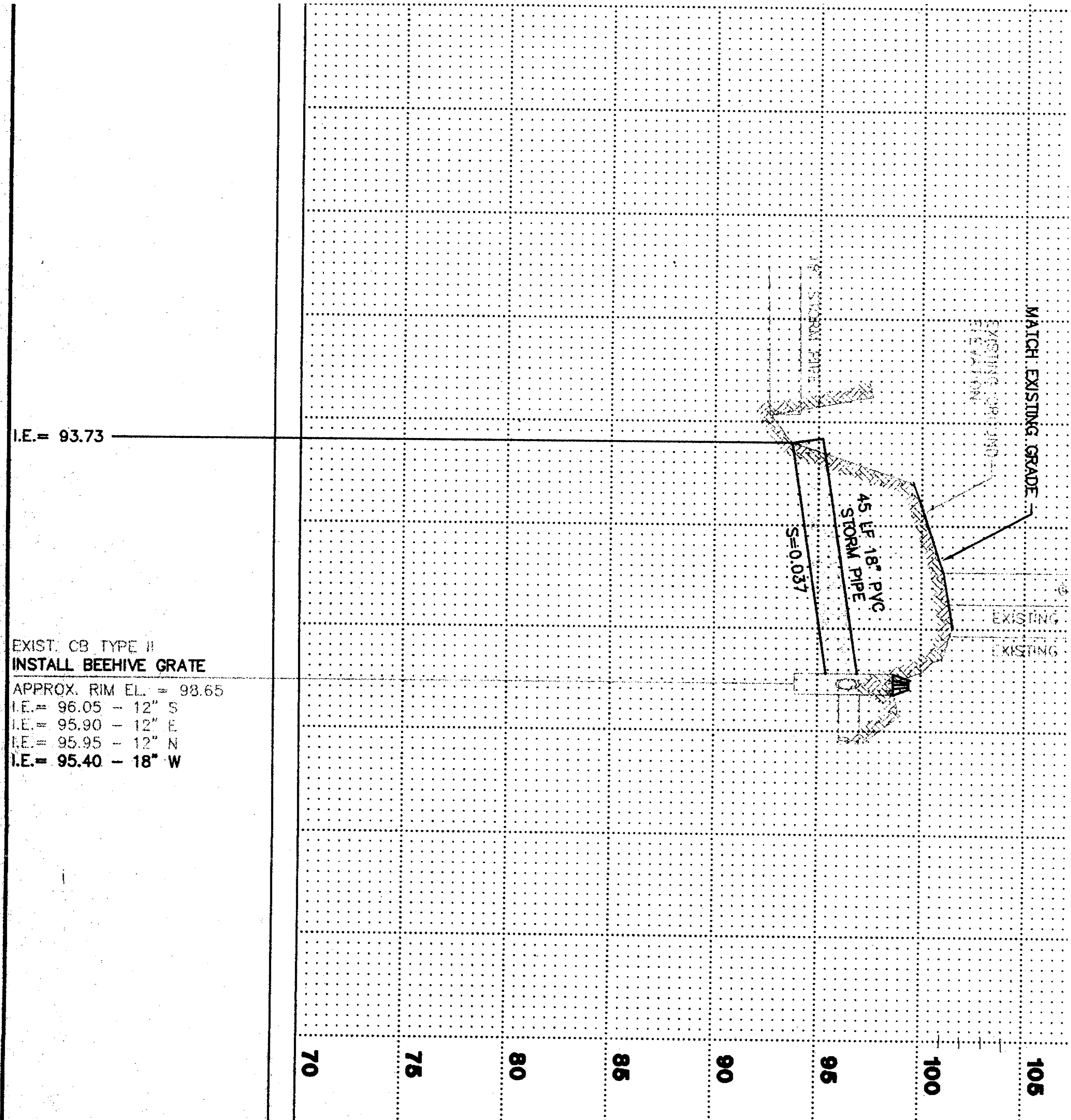
1. THE DEPTH OF COVER OF EXISTING UTILITY CROSSINGS IS UNKNOWN AND THEREFORE NOT SHOWN ON THE PROFILE. ADJUSTMENT OF THE WATERMAIN DEPTH MAY BE REQUIRED TO CROSS UNDER THE UTILITY.
2. THE CONTRACTOR SHALL PROTECT AND NOT DISTURB ANY PROPERTY CORNERS OR MONUMENTS.
3. SHADED AREA INDICATES LIMITS OF ASPHALT RESTORATION AND IMPROVEMENTS.
4. ALL LAYOUT OF WORK SHALL BE COORDINATED WITH THE CITY'S INSPECTOR PRIOR TO STARTING WORK ON THIS SCHEDULE.
5. CONTRACTOR SHALL REPAIR ASPHALT CONCRETE PAVEMENT UPON COMPLETION OF WORK ON THIS SCHEDULE.



SCHEDULE J

CULVERT AT 11234 E RIVERSIDE DR

DATE: SEP. 2000



SHEET:	9
OF:	14
JOB NO.:	00432
DWG:	PLAN3

CITY OF BOTHELL
KING/SNOHOMISH COUNTY WASHINGTON

2000 STORM DRAINAGE
IMPROVEMENT PROJECTS
SCHEDULES I & J
103RD AVENUE DRY WELL
CULVERT AT 11234 E RIVERSIDE DR.

City of Bothell, 2000 St
Steve